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RACCOON RIVER AND WALNUT CREEK

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WEST DES MOINES AND DES MOINES, IOWA

LOCAL FLOOD PROTECTION PROJECT

AD-A237 926



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DESIGN MEMORANDUM

WITH ENVIRONMENTAL ASSESSMENT

JULY 1990

REVISED NOVEMBER 1990

REVISED JUNE 1991

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91-04341



US Army Corps
of Engineers
Rock Island District

SYLLABUS

A General Reevaluation report was completed for the Raccoon River and Walnut Creek, Des Moines and West Des Moines, Iowa Local Flood Protection project in 1989. The project was authorized by Public Law 99-662 in 1986. The GRR reaffirmed a flood control project with a benefit-to-cost ratio of 1.8.

This report details the design, economics and environmental considerations of the recommended 100-year level of protection from Raccoon River and Walnut Creek. The 100-year plan is the Net Economic Development (NED) plan. Protection will be provided to approximately 900 urban arces, including 904 residei .ial, 227 businesses, and 11 public structures. The plan includ-s 4.0 miles of earthen levee, 1854 feet of concrete floodwall, 7 closure structures, 2 sandbag closure structures, 2 pumping stations, 4 ponding areas, 3 road ramps for access, and 6 road ramps for maintenance. The recreation portion of the project would consist of 2.8 miles of bicycle path, 2 bicycle ramps, 2 railroad crossings, 2 road crossings, 1 scenic vista, 1 parking lot, and 1 single lane boat ramp to the Raccoon River.

The total project cost is $16,392,000 with a resulting annual cost of $1,808,400. The annual benefits are $3,658,200 and the net benefits are $1,849,800. The flood control and recreational B/C ratios are 2.0 and 1.8 respectively.

The cities of Des Moines, West Des Moines and Clive, Iowa have recently installed a flood warning system on Walnut Creek and the Raccoon River. This warning system was installed in cooperation with the National Weather Service. The NWS issues flash flood alerts with real time data acquisition to warn residents and cities of impending flood situations.

This Design Memorandum recommends that the project be continued by preparing plans and specifications in FY 91 in order to be ready for a new start in FY 92.

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DESIGN MEMORANDUM
FOR
FLOOD CONTROL PROJECT
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA

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DESIGN MEMORANDUM
FOR
FLOOD CONTROL PROJECT
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA

1. PROJECT AUTHORIZATION.

A flood protection project for the cities of West Des Moines and Des Moines, Iowa, was authorized by the Water Resources Development Act of 1986, Public Law 99-662, 99th Congress, dated November 17, 1986. Funds were received in September 1989 to initiate the Design Memorandum.

The authorizing language contained under Title IV, Section 401, paragraph a. of the Act, is restated below:

TITLE IV - FLOOD CONTROL

SEC. 401 AUTHORIZATION OF PROJECTS

(a) AUTHORIZATION OF CONSTRUCTION. The following works of improvement for the control of destructive floodwaters are adopted and authorized to be prosecuted by the Secretary substantially in accordance with the plans and subject to the conditions recommended in the respective reports designated in this subsection, except as otherwise provided in this subsection:

Des Moines River Basin, Iowa and Minnesota

The project for flood control, Des Moines River Basin, Iowa and Minnesota: Report of the Chief of Engineers, dated July 22, 1977, at a total cost of $15,200,000, with an estimated first Federal cost of $10,900,000 and an estimated first non-Federal cost of $4,300,000. The Secretary shall, in consultation with appropriate Federal, State, and local agencies, study the feasibility of minimizing increased flood stages along Jordan Creek in the vicinity of the Chicago, Rock Island and Pacific Railroad Bridge and the implementation of non-structural and structural flood plain management techniques along the reach of Walnut Creek, including the improvement of channel capacity in the vicinity of Grand Avenue. In addition, the Secretary shall, in consultation with appropriate Federal, State, and local agencies, review the location of river access points and boat ramps.

2. PROJECT DESCRIPTION.

The project consists of a series of levees and floodwalls that protect portions of the cities of West Des Moines and Des Moines, Iowa. The project will provide 100-year protection from Walnut Creek and the Raccoon River. The levees will be constructed of semi-compacted impervious material with a 10 foot top width. Side slopes will be 1V on 3H. The total length of levees is 4.0 miles. Concrete floodwalls will be utilized where sufficient right-of-way does not exist to construct earthen levees. Several closure structures will

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be constructed across existing railroads and streets. Table No. A-3 includes a listing of closure structures and pertinent data pertaining to each.

The project is a cooperative effort between the Federal Government and the Cities of Des Moines and West Des Moines, Iowa. The Federal role consists mainly of planning, engineering and design, funding, and contracting for the construction of the various features. The basic responsibilities of the local sponsor are to provide planning input, right-of-way, maintaining and operating the completed works, and bear certain initial costs related to utility alterations and cash contributions.

The local cooperation requirements are discussed further in paragraph 10 and a copy of the Letter of Intent from the City is included in Appendix I.

A General Reevaluation Report was prepared by the district and approved by the North Central Division in August 1989. The GRR evaluated several levels of protection and determined that the 100 year plan was the National Economic Development (NED) plan. This plan is reaffirmed in this report and the current economic analysis is presented in Appendix B. The local sponsors support the (NED) plan.

3. PREVIOUS STUDIES.

1975 FEASIBILITY STUDY

In June 1975, the Rock Island District completed a report entitled Feasibility Study for Flood Damage Reduction and Related Purposes, Des Moines River Basin, Iowa and Minnesota.

The study was requested and authorized to investigate flooding and related water resource problems of the Des Moines River Basin.

Initial solutions investigated in the 1975 feasibility study included both structural and nonstructural alternatives for the Des Moines River Basin. One plan, which provides Standard Project Flood (SPF) protection for the city of West Des Moines and a portion of the City of Des Moines, was selected for recommendation for detailed design and construction and was the subject of the General Reevaluation Report (GRR) completed in 1989.

1977 FINAL ENVIRONMENTAL STATEMENT

In June 1977, the Rock Island District published a report entitled Final Environmental Statement, West Des Moines - Des Moines, Iowa, Des Moines River Basin, Local Flood Protection. The report addressed the environmental impact of the flood protection plan recommended in the 1975 Feasibility Report. A supplement to the Final Environmental Statement (i.e., the Supplemental FEIS) was prepared during the general reevaluation report to address modifications to the authorized plan.

1979 CONGRESSIONAL DOCUMENTS

The feasibility report was subsequently printed, in 1979, as Senate Document No. 96-36, and House Document No. 96-146, 96th Congress, 1st Session. In November 1986, Congress authorized the local flood protection project for the Raccoon River, Walnut Creek, and Jordan Creek areas of West Des Moines and Des Moines, Iowa, which is the subject of this Design Memorandum.

1989 GENERAL REEVALUATION REPORT

In July 1989, the Rock Island District published a report entitled, General Reevaluation Report for Flood Control Project, Raccoon River and Walnut Creek, West Des Moines - Des Moines, Iowa, with Final Supplement No. 1 to the Final Environmental Impact Statement. The report studied several levels of protection and determined the NED plan to be the 100 year level of protection. The benefit to cost ratio was 1.8 for flood protection and 1.3 for recreation. The Record of Decision (ROD) was signed July 30, 1990 finalizing supplement No. 1 to the FEIS.

4. STUDY PURPOSE AND SCOPE. The purpose of this report is to document changes from the General Reevaluation Report and to provide a basis for the preparation of plans and specifications. The primary purpose of the project is to reduce damages caused by flooding along Walnut Creek and the Raccoon River. The report includes the views of local interests as well as the technical analysis for hydrology and hydraulics, geotechnical, and structural. A detailed cost estimate, an economic analysis, and an environmental assessment as well as other subjects are covered in the appendices of this report.

5. REFERENCES. Several regulations were utilized in the compilation of the DM. A few basic ones are listed below:

ER 1110-2-1150	Engineering and Design - Engineering After Feasibility Studies, 1984
EC-1110-2-265	Engineering and Design - Engineering and Design of Civil Works Projects, 1 September 1989

6. INVESTIGATIONS.

Surveying and Mapping. Additional data has been obtained on the project since the project formulation in the GRR. The Corps obtained aerial surveying data in the form of topographic maps from the City of West Des Moines, Iowa. The mapping included one-foot topographic maps of the City including the portion of the project along the Raccoon River. The topographic interpretation was done by the firm Analytical Surveys Incorporated (ASI) of Colorado Springs, CO. The district further contracted with ASI to provide two-foot contours of the Des Moines, Iowa portion and the northern portion of the West Des Moines levee alignment. The district also purchased the digital input files used to generate the contour information. This data was used to generate the levee alignments and levee volumes through the use of three dimensional digital terrain model (DTM) computer analysis. The plan and

profile sheets for this project reflect the recent survey data and computer generated alignments.

The Cities of Des Moines and West Des Moines Iowa utilize a local city datum. The topographic data was supplied using this datum. Our local cost sharing partners prefer that we use the city datum in the development of this project. For this reason, the majority of this report has been formulated using the Des Moines City datum. By using this datum, our local sponsors will be able to relate flood forecasts in the area to local datums and city crews will be able to relate closure elevations in the Operation and Maintenance Manual to a datum they are familiar with. All existing utilities in the cities are also on this datum.

Geotechnical. An extensive geotechnical exploration program was undertaken to more accurately define the subsurface materials present along the levee alignment, in potential borrow areas and in ponding areas. The district contracted with Indeco of Iowa to perform the drilling. A geologist from the district office was present during the three week exploration work. The work was performed in September and October of 1989. The results of the exploration work are presented in Appendix C of this report.

Hydraulic. The hydrology and hydraulics for the project has been rerun based on the revised survey data obtained. Bridge routines have been refined along Walnut Creek based on new information and several clean out proposals and new bridge proposals. This information is covered in detail in Appendix A.

Highway Modifications. The Iowa Department of Transportation (IDOT) is preparing for improvements to a main north - south highway that has some impacts on the flood control project. Highway 28 (63rd Street) is currently only 2 lanes wide south of Grand Avenue. The IDOT plans to improve the highway to 4 lanes wide and begin construction in 1993. Early indications from the IDOT led us to believe that improved geometrics and new bridges would be constructed in the area of Grand Avenue and 63rd Street. This allowed for the bridge at Grand Avenue and Walnut Creek to be replaced and create a greater waterway opening. This plan also called for channel straightening and clearing that would improve the hydraulics of Walnut Creek. The cities of Des Moines and West Des Moines, Iowa are working closely with the IDOT to accomplish a bridge replacement at Grand Avenue in conjunction with the 4 lane improvement of 63rd Street. This improvement is totally independent of the flood control project. District personnel have attended several planning meetings to insure that transportation plans do not adversely affect our flood control plans. The highway improvements along 63rd Street near the Raccoon River will result in a highway grade raise which will reduce the frequency of a sandbag closure. This closure will now only be about 18 inches high.

Utilities. All available pertinent information on gas, electric, telephone, sewer and water facilities has been obtained from the utility companies and local cities. Data concerning railroads, natural gas, water lines and telephone have been collected and are presented on the plan and profile plates. Any formal correspondence with these utilities is contained in Appendix I. Contact was made with the Electric Company to discuss the power requirements for the proposed pumping station.

Cost Estimate. A MCACES code of accounts cost estimate is presented in Appendix D. The estimates are based on current price levels with appropriate contingencies to cover the level of detail and analysis that has been obtained thus far.

7. RECOMMENDED PROJECT PLAN (100 YEAR EVENT). The General Plan for the proposed flood protection project is shown on Plate 1. An index of the plan and profile plates is shown on Plate 3. Plates have been arranged so that they start at the west end of the project at the upstream tie-off of Jordan Creek and proceed along the Raccoon River and extend upstream along Walnut Creek.

The Jordan Creek tie-off consists of a six foot high levee that is offset from the main creek flow. The levee crosses the Chicago, and Pacific Railroad tracks with a sandbag closure (plate 4). It then parallels a local gravel road and railroad tracks for approximately 5,000 feet (plates 5-7). A closure structure is needed for a railroad spur that services a local Martin Marietta bulk material operation (plate 40). This closure will also allow for truck access to Martin Marietta and to Iowa Concrete Products. The levee continues to follow the railroad tracks until it reaches STA 70+00 (plates 7-9). At this location the levee continues south and east encompassing ponding area C (plate 26). A pumping station and gravity outlet (plate 27) will be constructed at the east end of the ponding area. The levee continues to the east until it intersects 63rd Street.

At the intersection of 63rd Street, a one and one-half foot sandbag closure is required across this improved highway (plate 11). At this point the levee continues into the City of Des Moines. The levee continues to the northeast and crosses the Chicago, Northwestern Railroad tracks with a double track closure structure (plate 41). The levee parallels the tracks to the east until it turns to the north and heads up along Walnut Creek (plates 12-14). The levee alignment follows an existing levee alignment on the west bank of Walnut Creek until it reaches 63rd Street about 600 feet south of Grand Avenue (plates 15-18). At this point, a wall will parallel 63rd Street until it intersects Grand Avenue (plate 19). At Grand Avenue Bridge, a closure structure will cross the bridge approach (plate 42). The wall will continue up along 63rd Street for 280 feet. At this point a pumping station will be located to handle the interior runoff of this area (plate 49). To the north 160 feet, the wall crosses the Norfolk and Southern Railroad tracks near Ashworth Road (plate 43). The wall will continue north for about 300 feet before crossing 63rd Street in a westerly direction. A double leaf swing gate closure structure is planned at this location (plate 44). A floodwall is planned to go around a Glen Gary brick building, located on Hoak Drive (plate 20). A levee is shown for the Hoak Drive portion of the project. The levee will be constructed on the east side of Hoak Drive until it passes the entrance to Wheeler Lumber. At this point the levee will be placed on top of Hoak Drive because of floodway encroachment problems. Hoak Drive will be closed to thru traffic as a result of this project. After proceeding 1000 feet along Hoak Drive, the levee will move to the west where it crosses Wheeler Lumber Company's property and the Norfolk and Southern Railroad. A closure structure is currently planned on Wheelers property and another across the railroad (plate 45, 46). The project ties into high ground to the west with a section of levee (plate 22).

8. DEPARTURES FROM THE GENERAL REEVALUATION REPORT. In developing the plan proposed in this Design Memorandum, some features of the GRR have been modified. These modifications are minor and are a result of recent findings during more detailed investigations of the project site. Some modifications are recommended as a result of cost saving measures. These modifications are listed below:

a. A spur line servicing the Martin Marietta plant near STA 39+00 was found to be active. Previous investigations believed that Martin Marietta was ceasing all activity in the area. The spur line is used to bring in bulk materials that are supplied to local concrete companies. A ramp had been proposed in this area for trucks to enter and depart. Since a gate is now proposed that would need to be open for rail traffic, it would be desirable for large gravel trucks and semi-truck trailers to also use this access point. The closure structure is located on the Raccoon River and there is enough warning time that the closure of this gate will not be a problem. It will be 30 feet wide with combined pavement and railroad tracks.

b. The Iowa Department of Transportation is planning on raising Highway 28 1.7 feet where our line of protection crosses the highway. This reduces the frequency of closure for the sandbag closure at this location.

c. The Grand Avenue area of the project is highly urbanized. Several commercial businesses have opposed the GRR alignment. The GRR alignment was set because of a State regulated floodway. Encroachment into the floodway would need to be mitigated. The cost of acquiring right-of-way, compensating owners for severance damages, and the size of closure structures have directed our efforts to change the floodway and mitigate the conveyance losses by cleaning the bridges out along Walnut Creek. The project cost remains essentially the same and the cost of real estate acquisition is significantly reduced. The public perception of the project will also be greatly enhanced.

d. Access to Wheeler Lumber and Beisser Lumber will be kept along Hoak Drive from the south.

9. DESCRIPTION OF PROPOSED STRUCTURES.

A. Closure Structures. This project includes 4 railroad closure structures and 2 street or roadway closure structures. Another closure structure is planned for the Wheeler Lumber Yard.

(1) Railroad Closures. Two railroad closures will be double track closures and 2 will be single track closures. The track closures would involve either a single steel gate or double steel gate rotating on an end column. The tallest of these closures would be 7.6 feet tall. Typical details are shown on plates 40, 41, 43, and 46.

(2) Street Closures. Two street closures are planned in the Grand Avenue area of the project. Both cross major traffic arteries in the cities of Des Moines and West Des Moines. Details of these closures are shown on

on plates 42 and 44. A closure structure in the Wheeler Lumber Yard is shown on plate 45.

(3) Pumping Stations. Two pumping stations are planned for the project. They will be of a submersible pump type. One will be capable of 20,000 gpm and the other 50,000 gpm. The pump optimization and selection is presented in Appendix A. A detailed design analysis of the pumping stations is presented in Appendix F.

10. REAL ESTATE REQUIREMENTS.
The local sponsors will need to acquire all necessary lands, easements, rights-of-way and relocations for the subject project. Each sponsor will be required to obtain the LERRD requirements within their city boundaries. The breakdown for such easements are estimated in the table below:

TABLE 1

ITEM	DES MOINES (AC)	WEST DES MOINES (AC)
Flood Protection Levee Easement	18.18	21.32
Road Easement (Boat Ramp)	1.25	0
Railroad Easement	0.35	.35
Drainage Ditch Easement	0	.65
Temporary Construction Easement	1.63	5.05
Utility Easement	0.7	2.62
Borrow Easement	5.0	40.0
Borrow Easement & Ponding Easement	8.0	41.11
Ponding Easement	0.0	2.3
TOTAL	35.11	113.65

One relocation of a business is anticipated in the Des Moines, Iowa portion of the project. Lands required for recreation are included in the levee easements and road easement above. These lands were accounted for in the gross appraisal.

11. LOCAL COOPERATION REQUIREMENTS.
The Cities of Des Moines and West Des Moines, the sponsoring agency for this project, would be required prior to the start of construction and in accordance with Section 221 of the Flood Control Act of 1970, Public Law 91-611, to enter into a written agreement that it will:

a. Provide during the period of construction a cash contribution of 5% of total project costs.

b. Provide all lands, easements and rights-of-way, and dredged material disposal areas, and perform all relocations of utilities and facilities (excluding railroad bridges and approaches thereto) determined by the Government to be necessary for construction of the project.

c. If the value of the contributions provided under paragraphs a. and b. above represents less than 25% of total project costs, the Sponsor shall provide, during the period of construction, an additional cash contribution in

the amount necessary to make its total contribution equal to 75% of total project costs.

d. Hold and save the Government free from all damages arising from the construction, operation, and maintenance of the project, except for damages due to the fault or negligence of the Government or its contractors.

e. Operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, in accordance with regulations or directions prescribed by the Government.

f. Provide or pay to the Government the cost of providing all retaining dikes, waste weirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged material disposal areas necessary for construction of the project.

g. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Public Law 100-17, and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way for construction and subsequent operation and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

h. Comply with all applicable Federal and State Laws and regulations, including Section 601 of Title VI of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

i. Perform, or cause to be performed, any environmental audits determined by the Government to be necessary on lands to be provided to the Government by the Sponsor for construction of the project.

j. If any lands provided to the Government by the Sponsor are found to contain hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act, the Sponsor shall be solely responsible for any and all necessary associated clean up and response costs as defined in the statute.

k. Prevent encroachment on any of the flood protection structures, including ponding areas, and if ponding areas are impaired, provide substitute storage capacity or equivalent pumping capacity promptly without cost to the United States.

l. Participate in and comply with applicable Federal flood plain management and flood insurance programs.

m. Publicize flood plain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain and in adopting such regulations as may be necessary to ensure compatibility between future development and protection levels provided by the project.

n. At least annually, inform affected interests of the limitations of the protection afforded by the project.

In addition, the sponsor must grant the Government a right to enter, at reasonable times and in a reasonable manner, upon land which it owns or controls for access to the project for the purpose of inspection and for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project if such inspection shows that the sponsor for any reason is failing to fulfill its obligations under the Agreement and has persisted in such failure after a reasonable notice in writing by the Government, delivered to the sponsor. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Government in such event shall operate to relieve the sponsor of responsibility to meet its obligations as set forth in the Agreement or to preclude the Government from pursuing any other remedy at law or equity.

12. CONSTRUCTION STAGES.

It is currently proposed to construct the project in three stages. Stage I would be built in West Des Moines from Ashworth Road north along Hoak Drive and tie-off to high ground as shown on plate 22. Stage II would follow the Raccoon River west of 63rd Street until it ties off on Jordan Creek in West Des Moines. Stage III would include the Des Moines portion of the project south of Ashworth Road following Walnut Creek downstream turning west along the Raccoon River and tieing off on 63rd Street.

13. SCHEDULE OF DESIGN AND CONSTRUCTION.

Signing of the Local Cooperation Agreement by the local sponsors is scheduled for October 1991. Submission of the right-of-way drawings to the cities is scheduled for March 1992. Subject to the availability of funds and right-of-way, the project is otherwise scheduled as follows:

Item	Submit P & S	R.O.W. Available	Contract Award	Complete Construction
Stage I	Apr 91	Nov 92	Jan 93	Aug 94
Stage II	Mar 92	Nov 93	Jan 94	Jan 96
Stage III	Dec 92	Mar 94	May 94	May 96

14. OPERATION AND MAINTENANCE.

The project will be maintained and operated by local interests in accordance with Title 33 - Navigation and Navigable Waters, Chapter 2, Corps of Engineers, Department of the Army, Part 208 - Flood Control Regulations, Maintenance and operation of Flood Control Works. Local interests will be entirely responsible for the maintenance and operation of the project after the completed works have been transferred to them. An Operation and Maintenance manual will be issued to the Cities upon completion of the project. The Cities will be required to submit periodic reports of

inspection, maintenance, and operation to the District Engineer. The average annual non-Federal cost of operation and maintenance is estimated to be $34,000.

The following items were included in the operation and maintenance cost:

a. Levee maintenance - includes brush removal, erosion repairs and mowing.

b. Bridge Maintenance - includes dredging at bridge openings along Walnut Creek to maintain the necessary bridge opening to pass flood flows.

c. Pump station operating energy costs and replacement costs.

d. Pump station maintenance - includes trash removal, sump clean-out, maintenance and servicing of pumps, electrical system and gauges, and yard clean-up.

e. Early warning system maintenance.

15. ENVIRONMENTAL AND CULTURAL ANALYSIS.

As mentioned in paragraph 3, PREVIOUS STUDIES, a Final Environmental Statement was prepared in 1977. A supplement to the FEIS was prepared in 1989 for the GRR and the ROD for the supplement was signed in June 1990. Because of a refinement of the project alignment in the Grand Avenue area, an environmental assessment (EA) was prepared. This EA is presented in this report, Agency coordination has also been presented. The EA is presented in Appendix H.

16. PROJECTED COSTS.

A summary of the project costs are shown in Table 2. A detailed explanation of the project costs, contingencies, and a comparison with previous cost estimates is shown in the cost Appendix D, Detailed Cost Estimate.

TABLE 2

Cost Estimate Summary

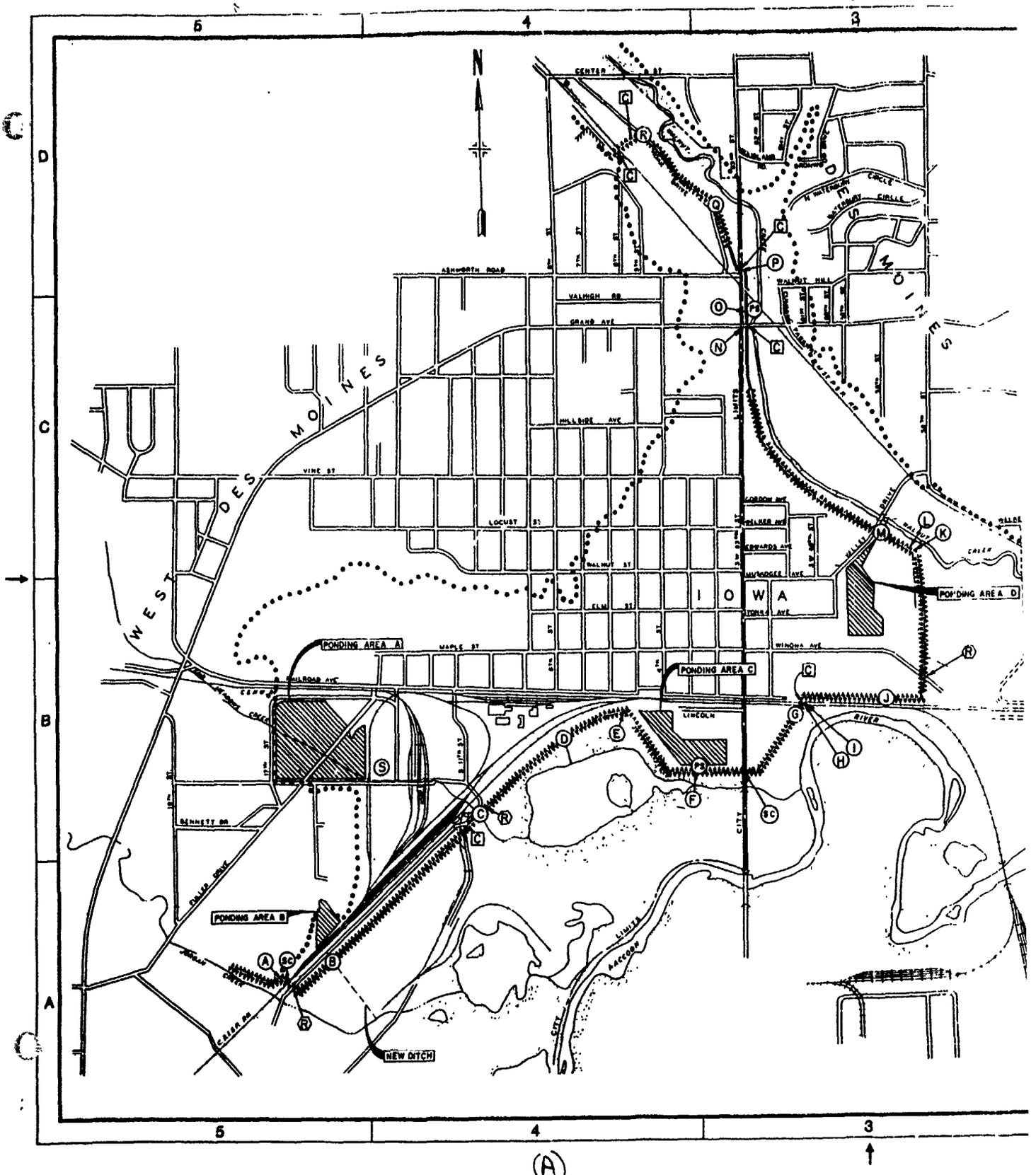
Flood Control Category	WDM	DM	Combined Totals
Real Estate (LERR)	1,298,000	689,000	
Levees	1,556,900	1,128,100	
Floodwalls	1,251,300	--	
Closure Structures	677,300	184,700	
Bridge Cleanouts	202,500		
Road Ramps	38,600	14,100	
Storm Drainage	3,179,000	213,000	
Utilities	134,700	251,200	
Relocations	366,600	47,900	
Revegetation	298,900	52,700	
Pumping Station	1,085,500		
Subtotal	10,089,300	2,580,700	
E & D	1,821,200	465,800	
S & A	822,600	210,400	
Total Flood Control	12,733,100	3,256,900	$15,990,000
Recreation Category			
Real Estate (LERR)	17,500	7,500	
Bicycle Path	158,200	65,700	
Bicycle Ramps	11,000	3,500	
Vista	6,300		
Parking Lot		51,800	
Boat Ramp		31,500	
Subtotal	193,000	160,000	
E & D	15,300	12,700	
S & A	11,500	9,500	
Total Recreation First Costs*	219,800	182,200	$ 402,000
TOTAL PROJECT FIRST COSTS			$16,392,000

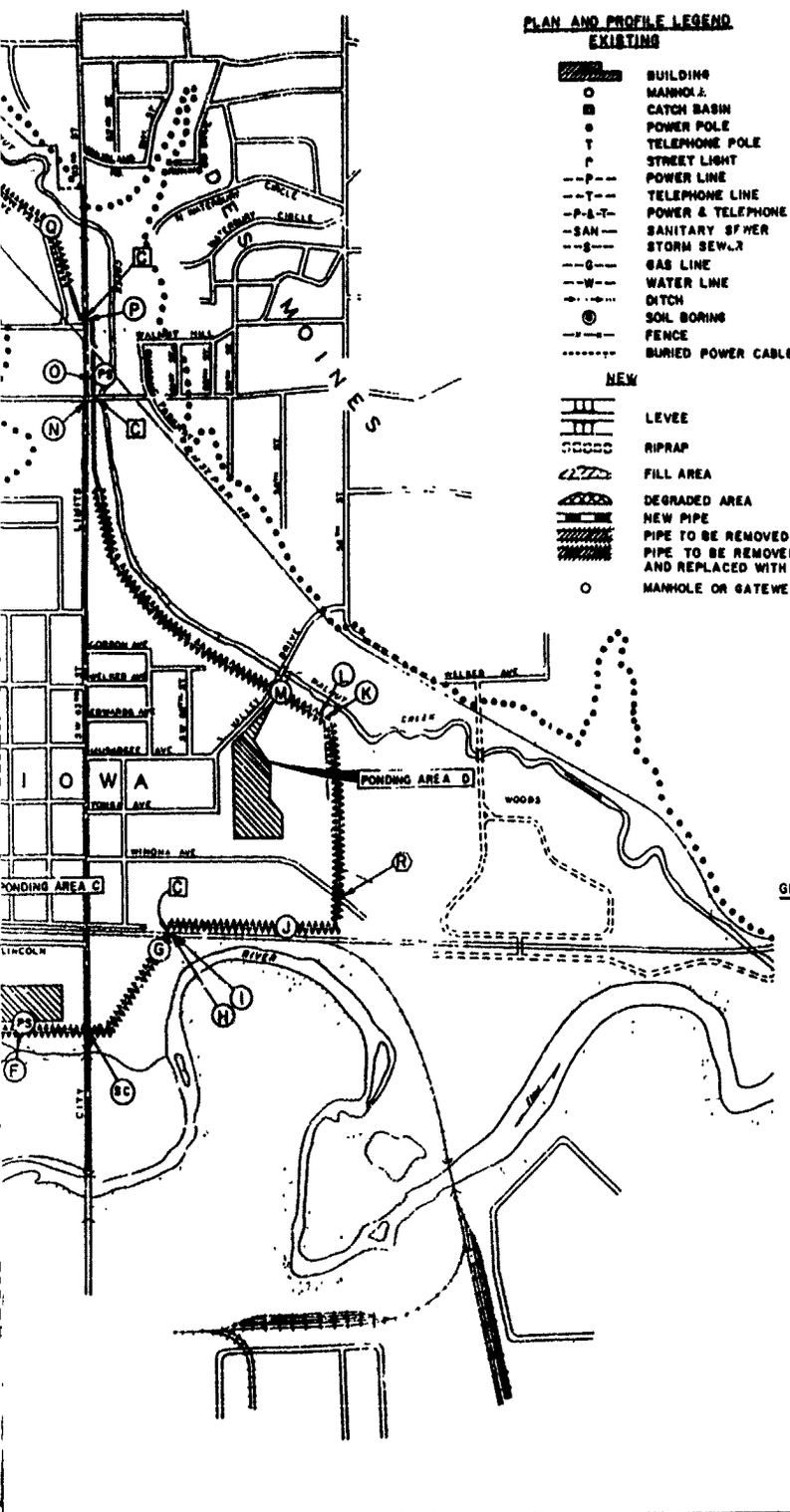
* All cost figures are rounded to the nearest $100.00.

17. RECOMMENDATION.

Based on careful consideration of social, cultural, environmental, and economic impacts, I recommend that the local flood protection project be constructed substantially as described in this DM. Furthermore, I certify that the proposed design in this DM is the most cost effective for this project based on a thorough technical analysis and evaluation of costs. I also recommend approval of this report allowing implementation of the project subject to cost sharing and financing arrangements as outlined in this report and that necessary Federal funds be made available.

Vincent Ferraro
Major, U.S. Army
Acting District Engineer


5
4
3
D
C
B
A
N
DES MOINES
WEST DES MOINES
IOWA
PONDING AREA A
PONDING AREA B
PONDING AREA C
PONDING AREA D
NEW DITCH
GRAND AVE
VINE ST
LOCUST ST
WALNUT ST
ELM ST
MAPLE ST
WINONA AVE
LINCOLN
RIVER
CITY LIMITS
(A)



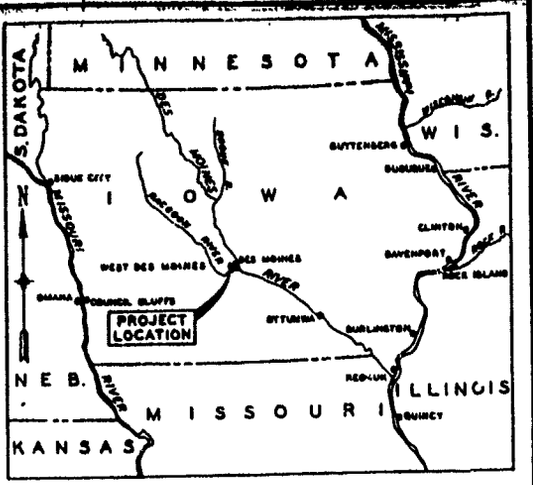
PLAN AND PROFILE LEGEND

EXISTING

- BUILDING
- MANHOLE
- CATCH BASIN
- POWER POLE
- TELEPHONE POLE
- STREET LIGHT
- —P— POWER LINE
- —T— TELEPHONE LINE
- —P-T— POWER & TELEPHONE LINE
- —SAN— SANITARY SEWER
- —S— STORM SEWER
- —G— GAS LINE
- —W— WATER LINE
- DITCH
- SOIL BORING
- FENCE
- BURIED POWER CABLE

NEW

- LEVEE
- RIPRAP
- FILL AREA
- DEGRADED AREA
- NEW PIPE
- PIPE TO BE REMOVED
- PIPE TO BE REMOVED AND REPLACED WITH NEW
- MANHOLE OR GATEWELL



VICINITY MAP

SCALE IN MILES

LEGEND:

- NEW LEVEE
- EXISTING LEVEE TO BE IMPROVED
- NEW FLOODWALL
- (PS) PROPOSED PUMPING STATION
- PONDING AREA
- (A) GATEWELL
- (SC) SANDBAG CLOSURE
- [C] CLOSURE STRUCTURE
- LIMITS OF FLOODING (100 YEAR FREQUENCY)
- (R) ROAD RAMP

GENERAL PLAN AND PROFILE NOTES:

1. TOPOGRAPHY WAS REPRODUCED FROM AERIAL PHOTOGRAPHY FLOWN IN 1980.
2. ALL ELEVATIONS ARE BASED UPON CITY DATUM. THE CONVERSION TO SEA LEVEL DATUM OF 1929 IS: ZERO GAGE (CITY DATUM) = EL. 773.8 (DATUM OF 1929).
3. CONTOURS ARE AT 1 OR 2 FOOT INTERVALS.
4. UNDERGROUND FACILITIES AND STRUCTURES AND ALL UTILITIES HAVE BEEN PLOTTED FROM AVAILABLE DATA AND SURVEYS IT IS LIKELY THAT OTHERS WILL BE ENCOUNTERED.

0' 700' 1400' 2100'

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by
Drawn by
Checked by
Quantities by
Approved by

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

GENERAL PLAN - FLOOD CONTROL

Scales: 1" = 700'

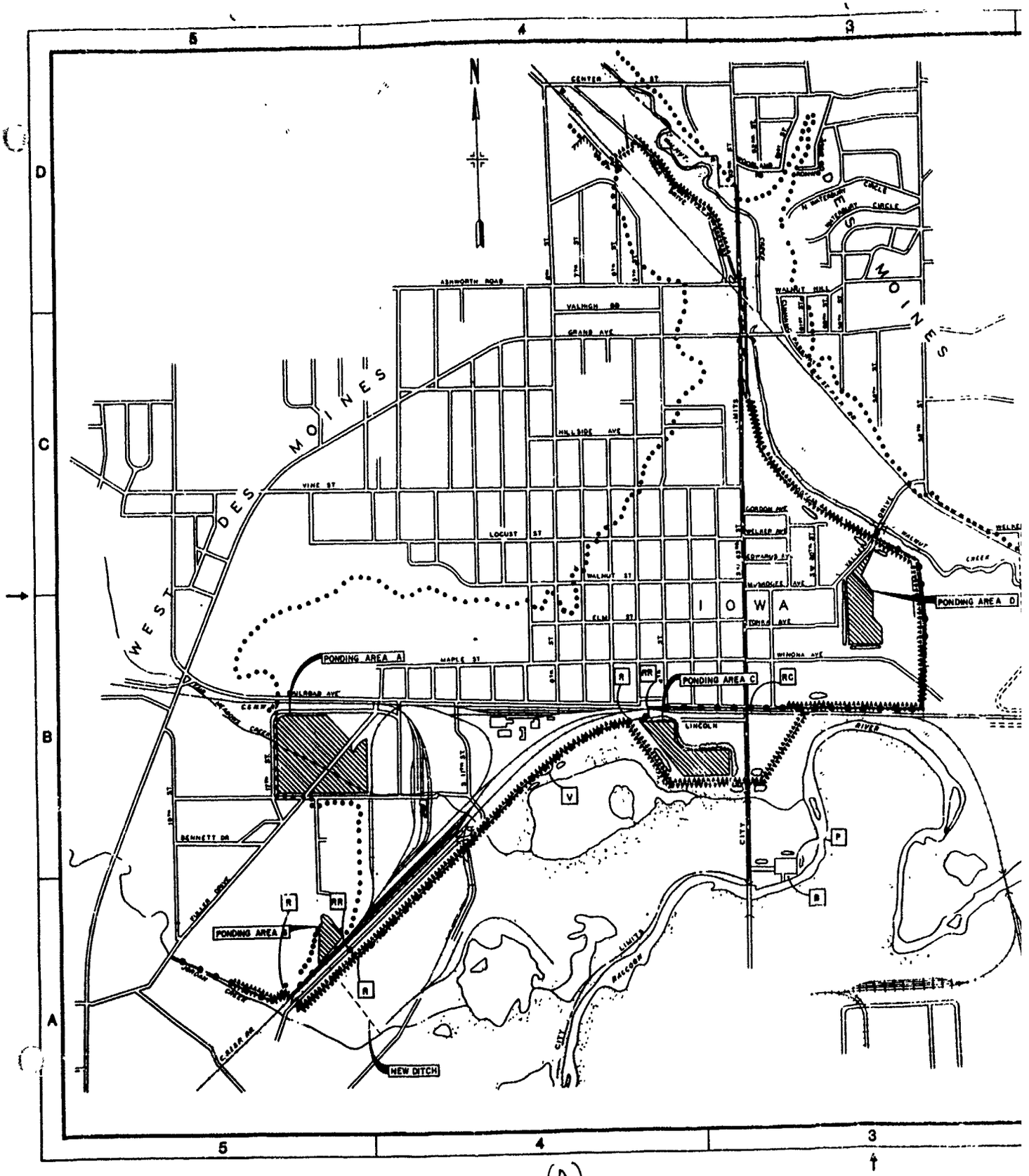
Sheet reference numbers

Drawing Code

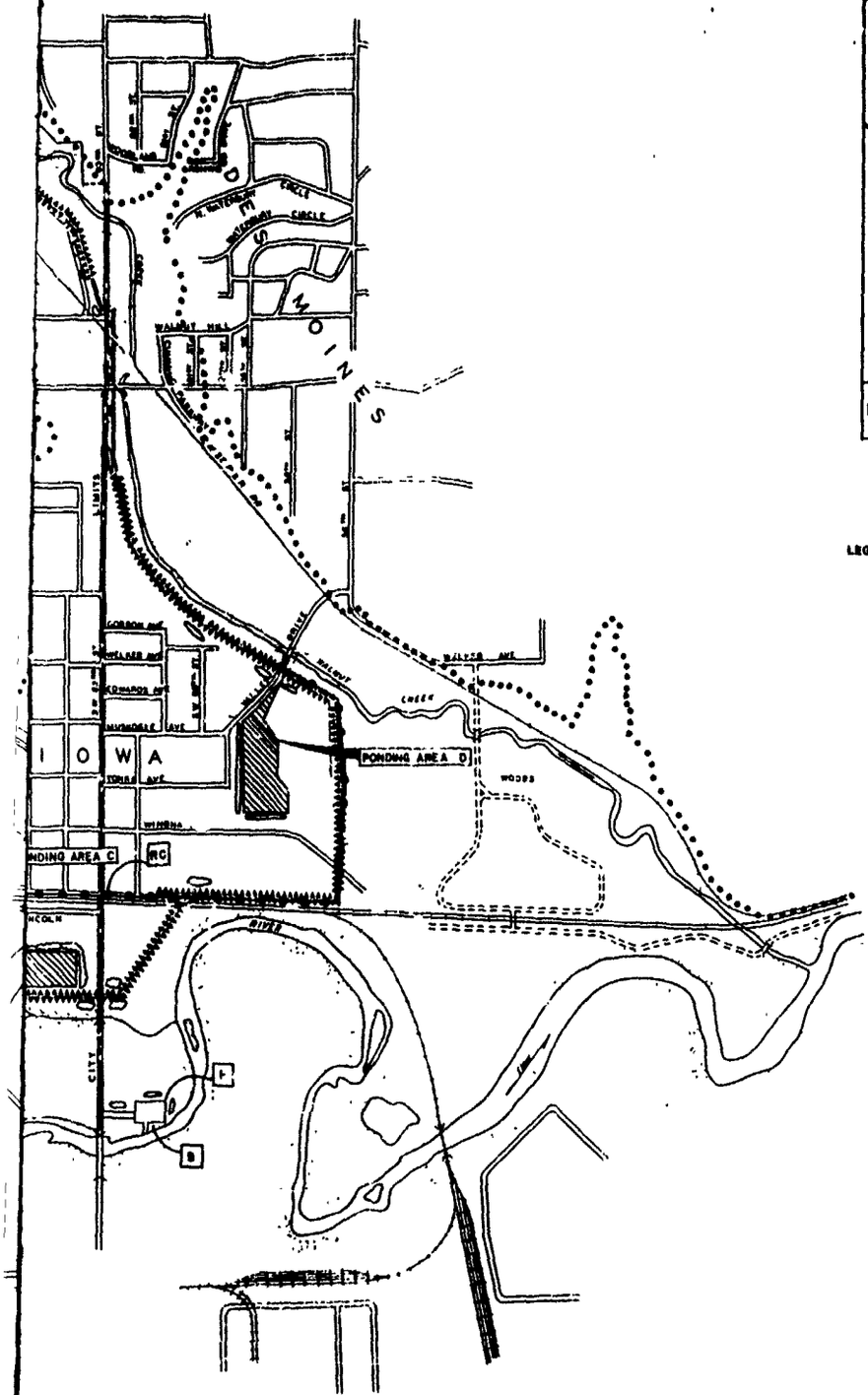
Sheet __ of __

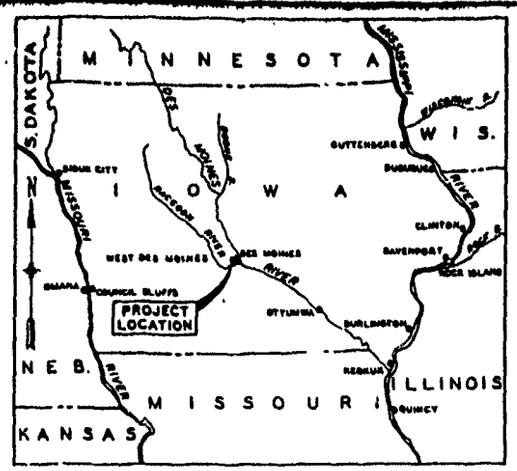
PLATE 1

(B)


5
4
3
D
C
B
A
N
WEST DES MOINES
DES MOINES
IOWA
CENTER ST
ASHWORTH ROAD
VALMOR RD
GRAND AVE
HILLSIDE AVE
VINE ST
LOCUST ST
WALNUT ST
ELM ST
MAPLE ST
RAILROAD AVE
WINONA AVE
LINCOLN
BENNETT DR
EASTER DRIVE
CEDAR DR
WALNUT CREEK
RACCOON RIVER
CITY LIMITS
PONDING AREA A
PONDING AREA B
PONDING AREA C
PONDING AREA D
NEW DITCH
R
RR
RC
V
P
B

(A)





VICINITY MAP

SCALE IN MILES

LEGEND :

- R BIKE RAMP
- RR RAILROAD CROSSING
- V VISTA
- RC ROAD CROSSING
- P PARKING LOT
- B BOAT RAMP
- TRAIL
- REVEGETATION

0' 700' 1400' 2100'

Symbol	Revisions Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by
Drawn by
Checked by
Recommended by
Approved by

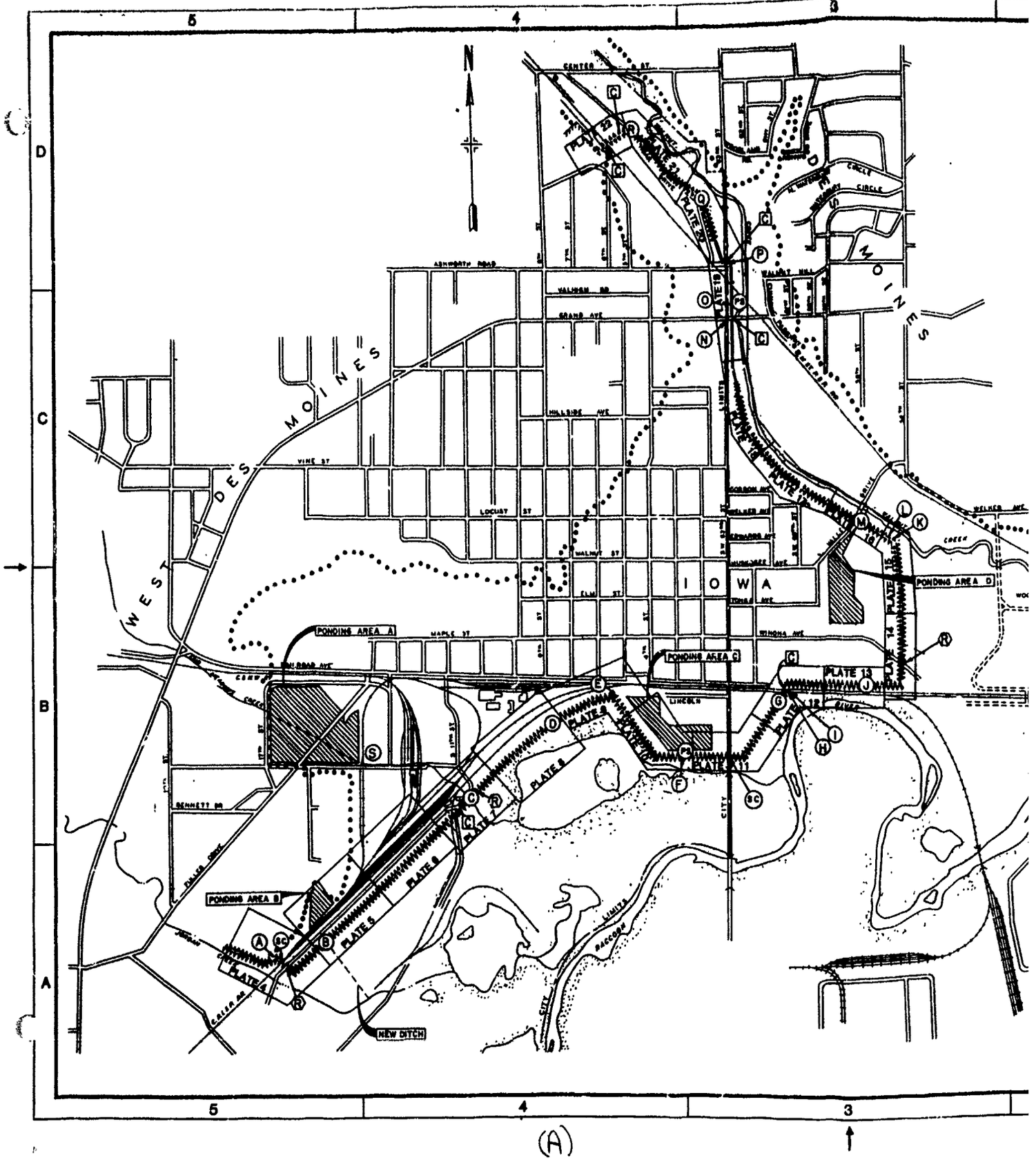
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

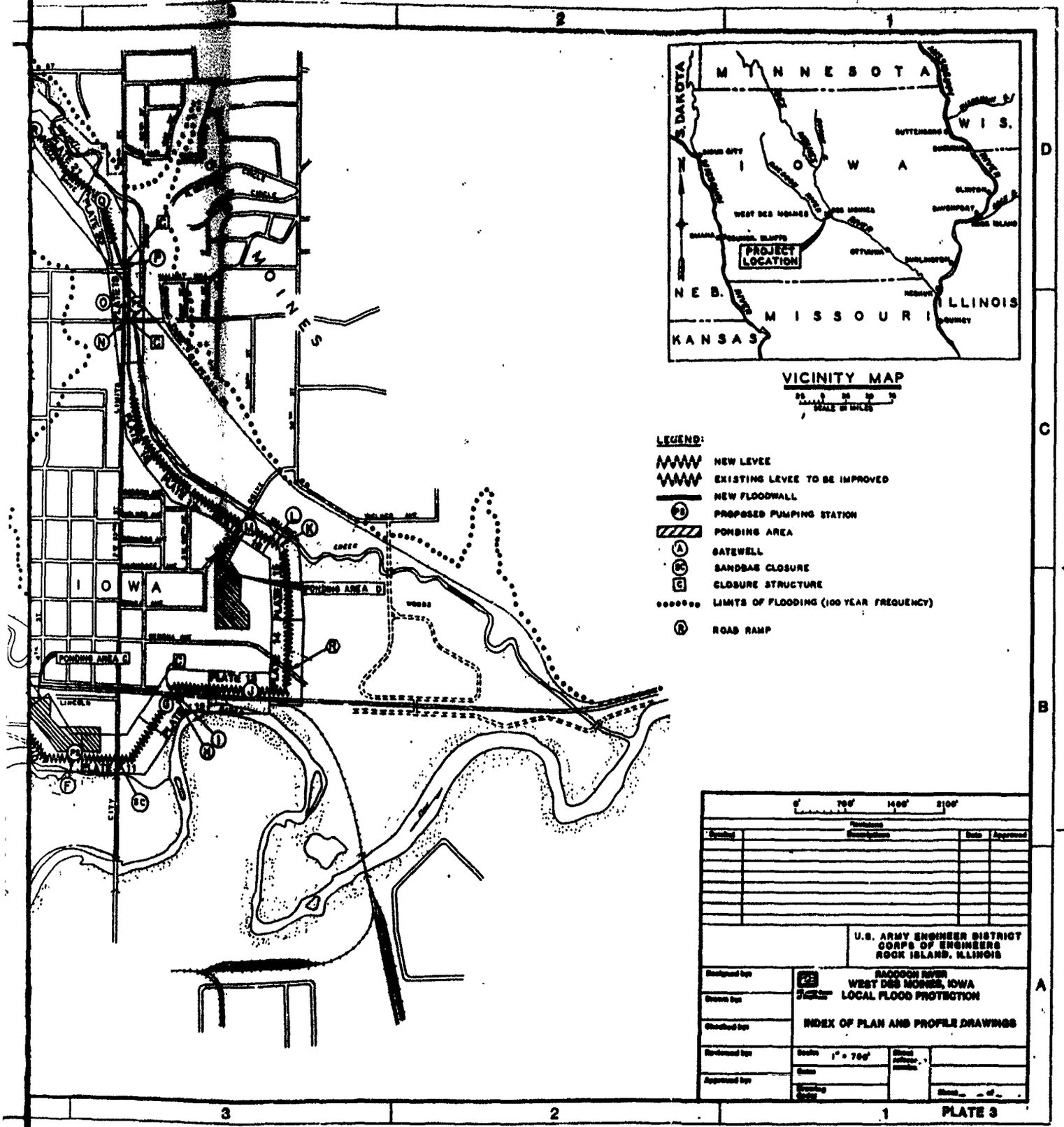
GENERAL PLAN - RECREATIONAL AND REVEGETATION

Scale 1" = 700'
Date
Drawing Code
Sheet reference number
Sheet ___ of ___

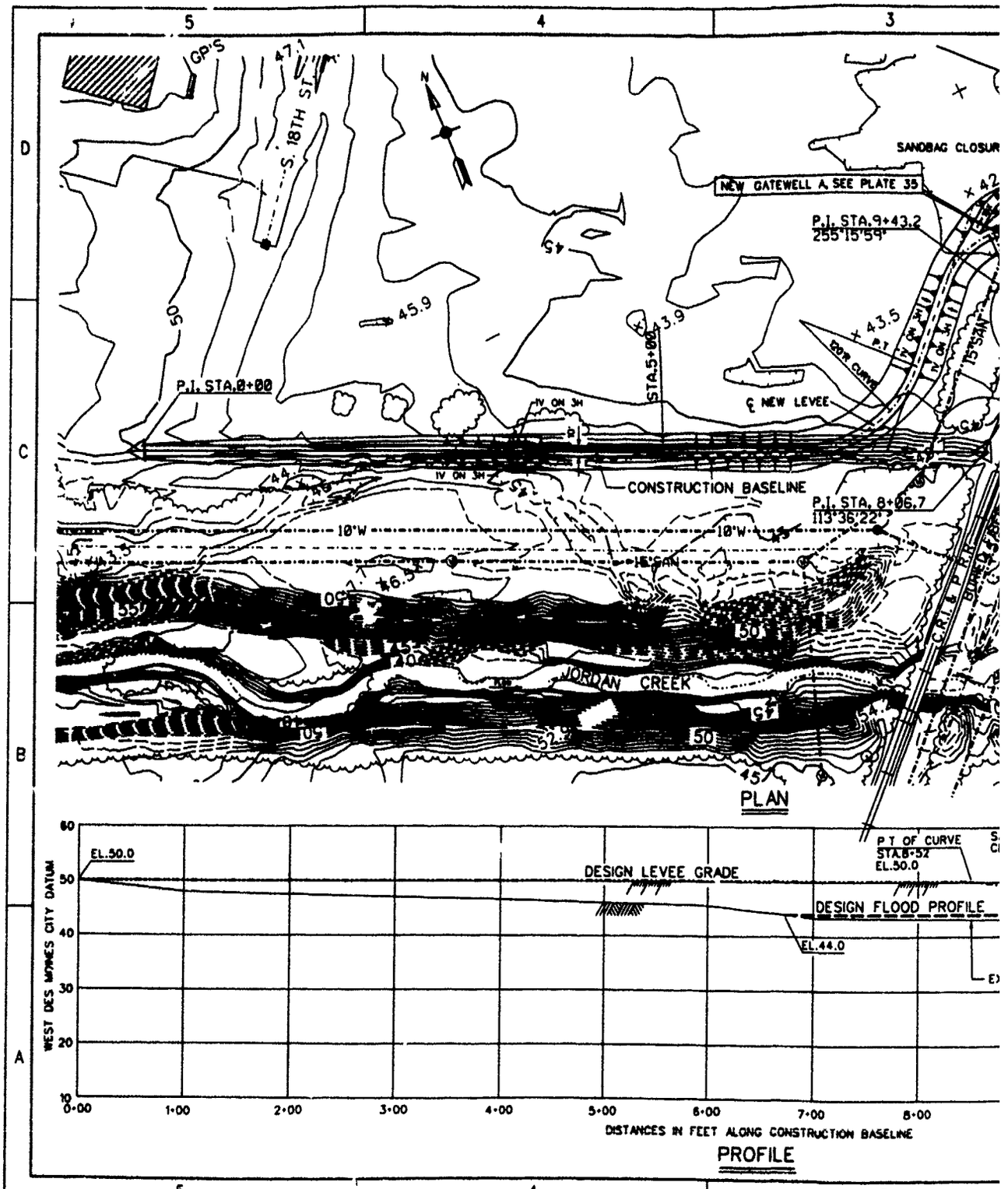
PLATE 2

(B)

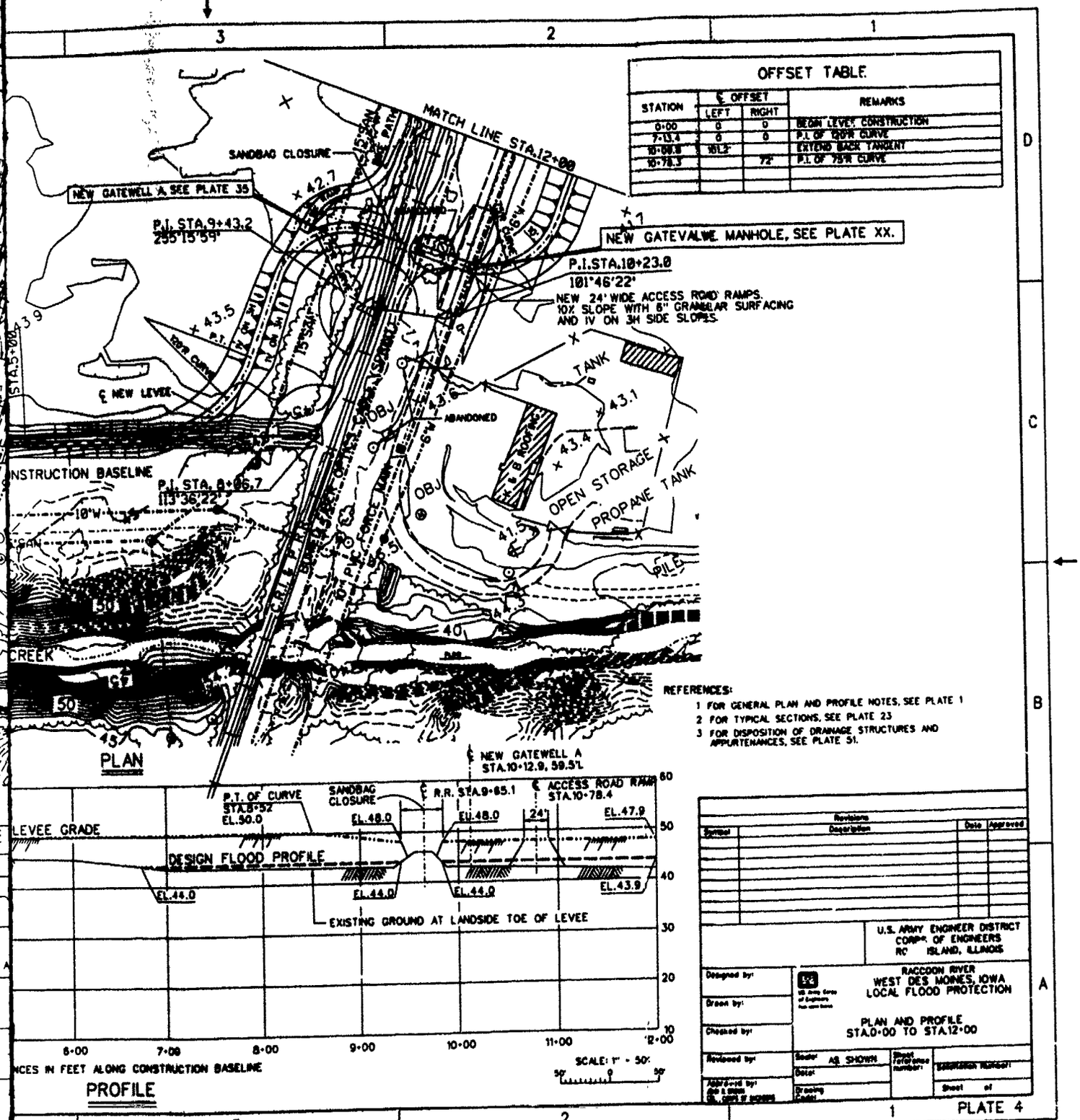

5
4
3
D
C
B
A
N
WEST DES MOINES
DES MOINES
IOWA
PONDING AREA A
PONDING AREA B
PONDING AREA C
PONDING AREA D
NEW DITCH
PLATE 1
PLATE 2
PLATE 3
PLATE 4
PLATE 5
PLATE 6
PLATE 7
PLATE 8
PLATE 9
PLATE 10
PLATE 11
PLATE 12
PLATE 13
PLATE 14
PLATE 15
PLATE 16
PLATE 17
PLATE 18
PLATE 19
PLATE 20
PLATE 21
PLATE 22
PLATE 23
VINE ST
LOCUST ST
WALNUT ST
ELM ST
MAPLE ST
GRAND AVE
HILLSIDE AVE
WALNUT HILL
WINONA AVE
LINCOLN
WALKER AVE
CENTER ST
ASHWORTH ROAD
BENNETT DR
CITY LIMITS
RACCOON RIVER
(A)


2
1
3
2
1
D
C
B
A
MINNESOTA
S. DAKOTA
WIS.
IOWA
NEB.
ILLINOIS
MISSOURI
KANSAS
PROJECT LOCATION
VICINITY MAP
SCALE OF MILES
LEGEND:
NEW LEVEE
EXISTING LEVEE TO BE IMPROVED
NEW FLOODWALL
PROPOSED PUMPING STATION
PONDING AREA
GATEWELL
SANDBAG CLOSURE
CLOSURE STRUCTURE
LIMITS OF FLOODING (100 YEAR FREQUENCY)
ROAD RAMP
PONDING AREA D
PONDING AREA C
IOWA
0' 700' 1400' 2100'
Revisions
Symbol
Description
Date
Approved
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION
INDEX OF PLAN AND PROFILE DRAWINGS
Designed by
Drawn by
Checked by
Reviewed by
Approved by
Scale 1" = 700'
Date
Submitted
Recommended
Sheet ... of ...
PLATE 3

(B)


5
4
3
D
C
B
A
GP'S
47.1
S. 18TH ST.
N
SANDBAG CLOSUR
NEW GATEWELL A, SEE PLATE 35
P.I. STA.9+43.2
255°15'54"
45
45.9
50
43.9
STA.5+00
43.5
P.T.
100' R CURVE
15°53'
P.I. STA.0+00
IV ON 3H
℄ NEW LEVEE
CONSTRUCTION BASELINE
P.I. STA. 8+06.7
113°36'22"
10'W
15' SAN
OC
55
50
45
JORDAN CREEK
PLAN
WEST DES MOINES CITY DATUM
60
50
40
30
20
10
EL.50.0
DESIGN LEVEE GRADE
P T OF CURVE
STA.8+52
EL.50.0
DESIGN FLOOD PROFILE
EL.44.0
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE

(A)



OFFSET TABLE			
STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
0+00	0	0	BEGIN LEVEE CONSTRUCTION
7+13.4	0	0	P.I. OF 120°R CURVE
10+86.8	161.2'		EXTEND BACK TANGENT
10+78.3		72'	P.I. OF 75°R CURVE

REFERENCES:

1 FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2 FOR TYPICAL SECTIONS, SEE PLATE 23
3 FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51.

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:

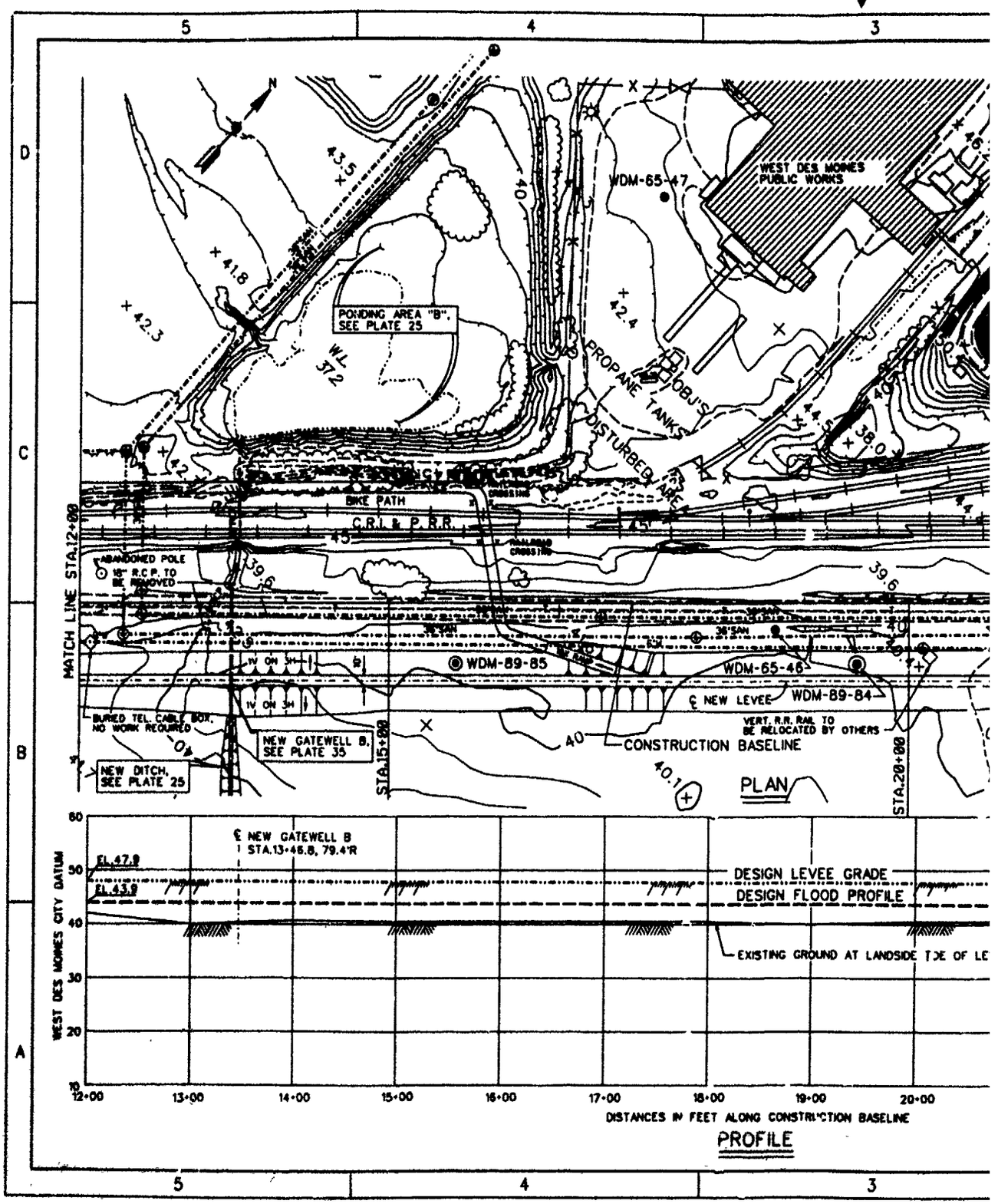
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

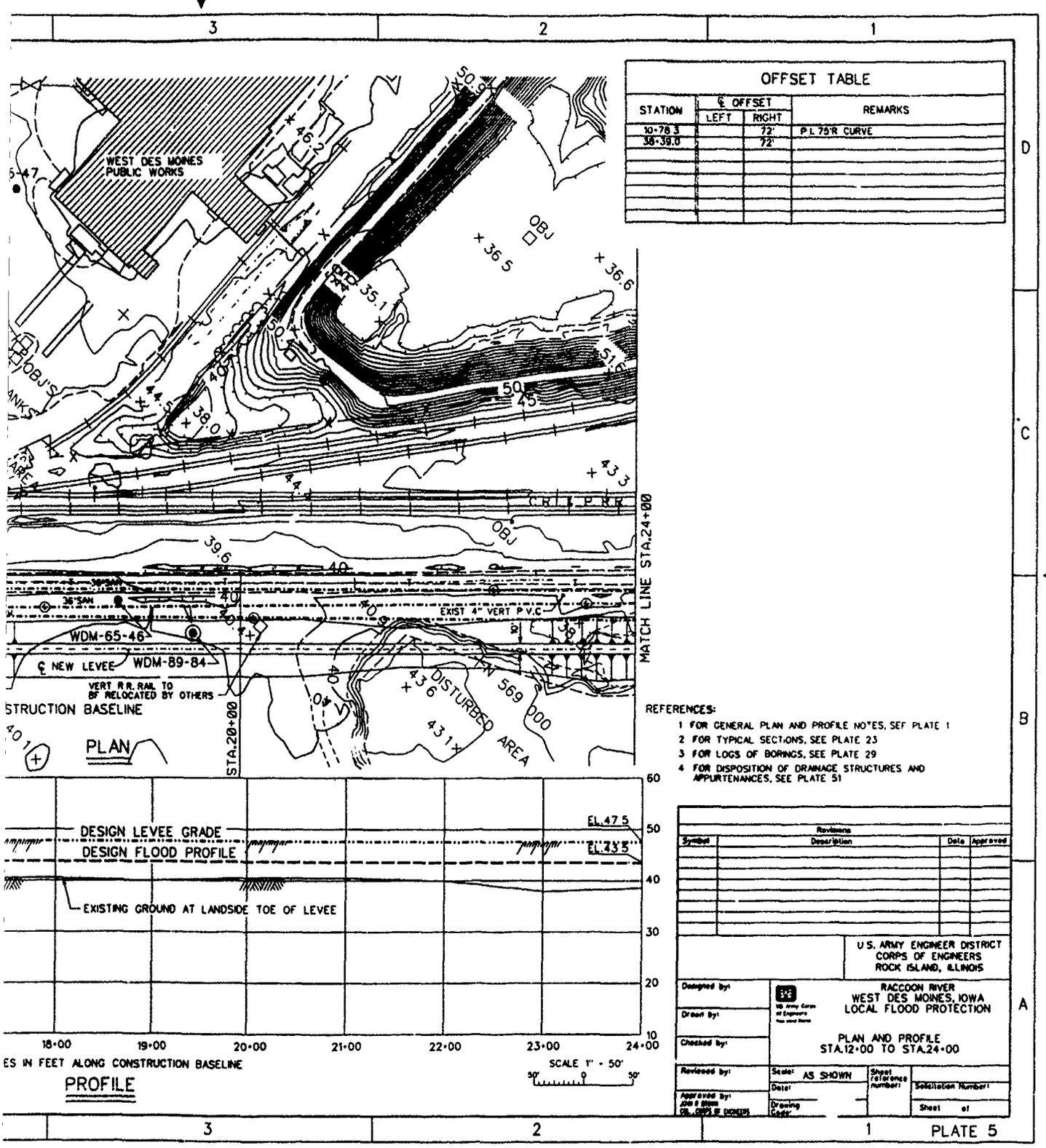
PLAN AND PROFILE
STA.0+00 TO STA.12+00

Scale: AS SHOWN
Date:
Drawing Control:
Sheet reference number:
Sheet of

PLATE 4

(B)


5
4
3
D
C
B
A
N
WEST DES MOINES PUBLIC WORKS
WDM-65-47
POINDING AREA "B", SEE PLATE 25
WL 372
PROPANE TANKS
OBJ'S
DISTURBED AREA
BIKE PATH
C.R.I. & P.R.R.
RAILROAD CROSSING
ABANDONED POLE
18" R.C.P. TO BE REMOVED
MATCH LINE STA.12+00
STA.15+00
STA.20+00
WDM-89-85
WDM-65-46
WDM-89-84
℄ NEW LEVEE
VERT. R.R. RAIL TO BE RELOCATED BY OTHERS
BURIED TEL. CABLE BOX, NO WORK REQUIRED
NEW GATEWELL B, SEE PLATE 35
NEW DITCH, SEE PLATE 25
CONSTRUCTION BASELINE
PLAN
℄ NEW GATEWELL B
STA.13+46.8, 79.4'R
EL.47.9
EL.43.9
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EXISTING GROUND AT LANDSIDE TOE OF LE
WEST DES MOINES CITY DATUM
60
50
40
30
20
10
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00
20+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE
(A)



OFFSET TABLE			
STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
10+78.3		72'	P.I. 75°R CURVE
38+39.0		72'	

REFERENCES:

1 FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2 FOR TYPICAL SECTIONS, SEE PLATE 23
3 FOR LOGS OF BORINGS, SEE PLATE 29
4 FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Revised by:
Approved by: JOHN G. BLUM, CHIEF, CORPS OF ENGINEERS

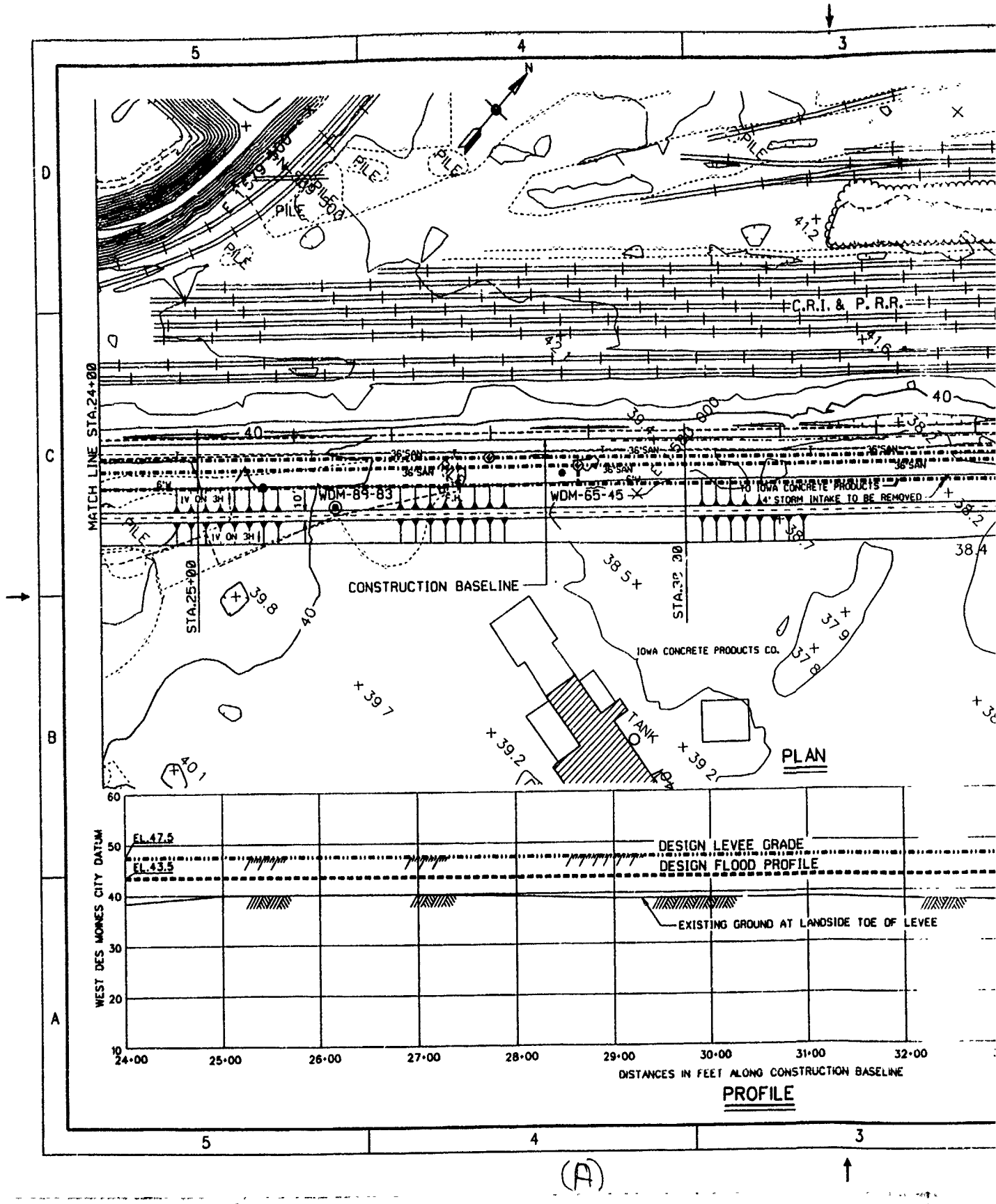
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

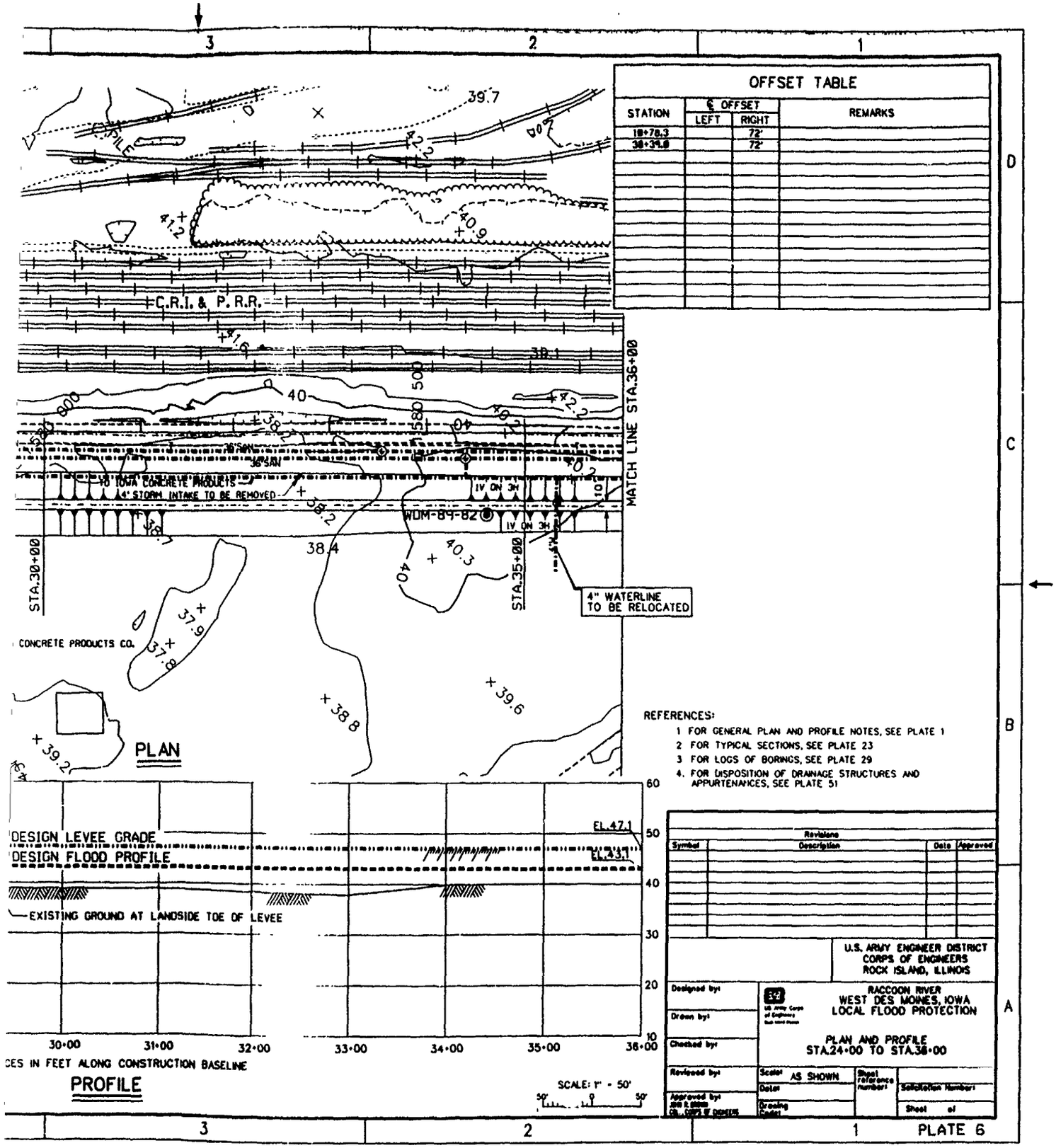
PLAN AND PROFILE
STA.12+00 TO STA.24+00

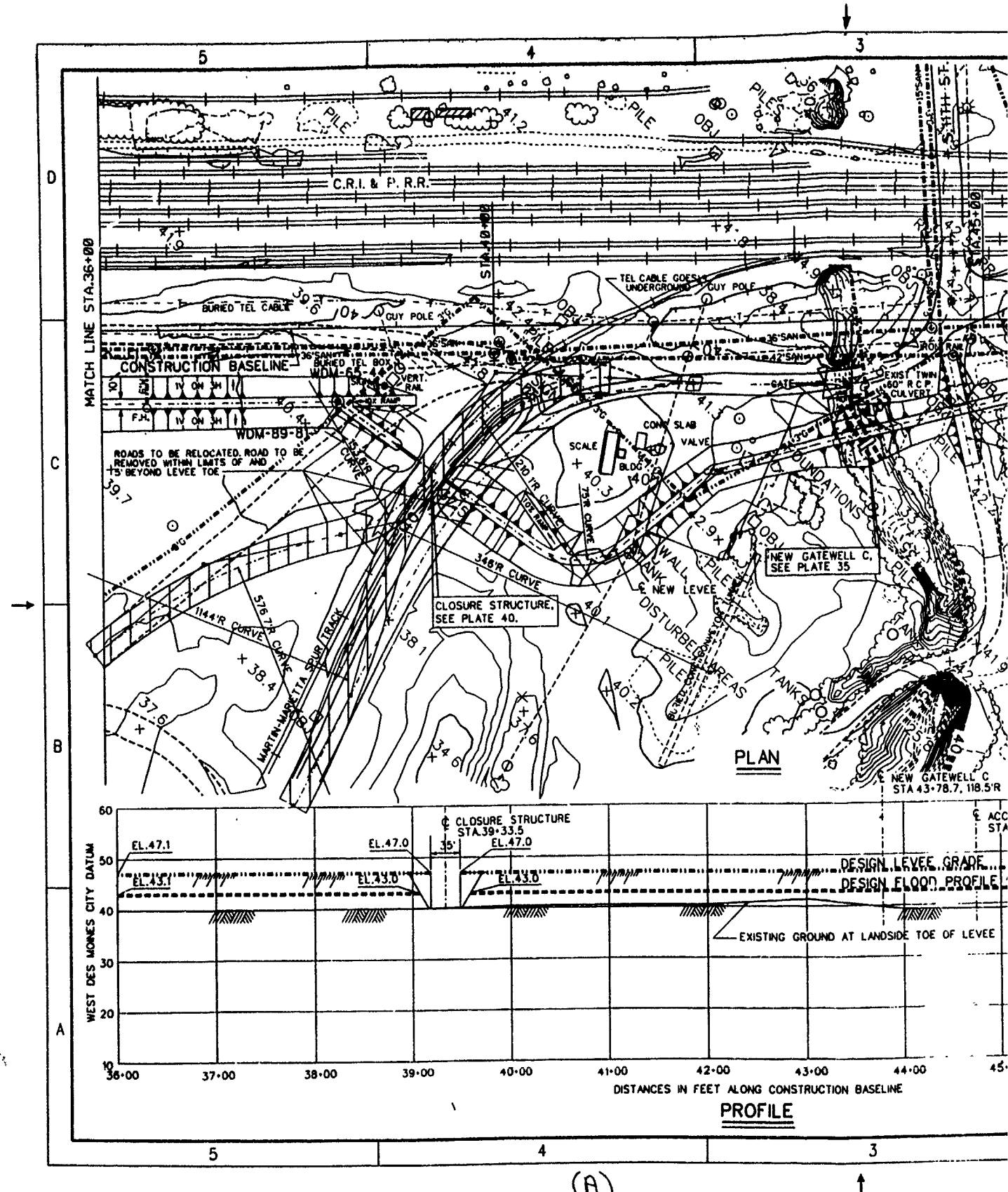
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Date:
Drawing code:
Sheet reference number:
Solicitation Number:
Sheet of

PLATE 5

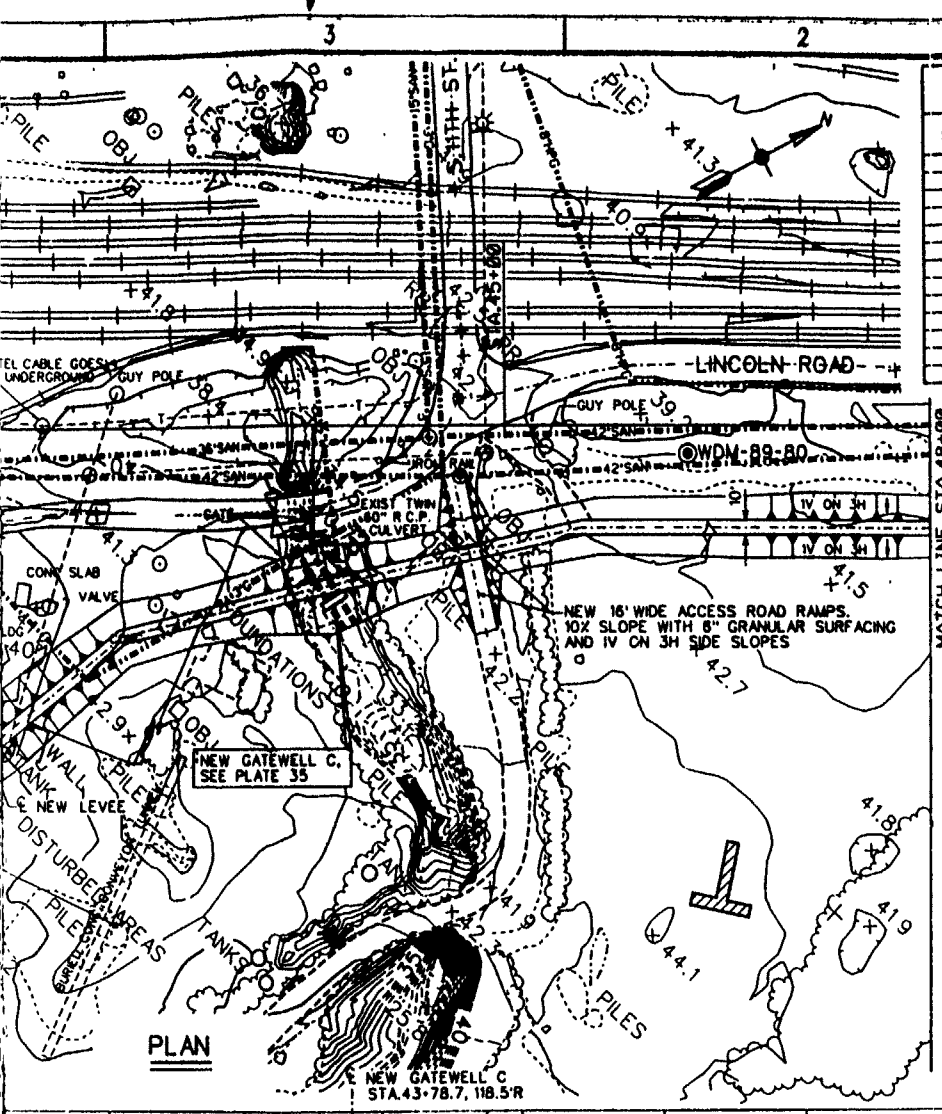
(B)

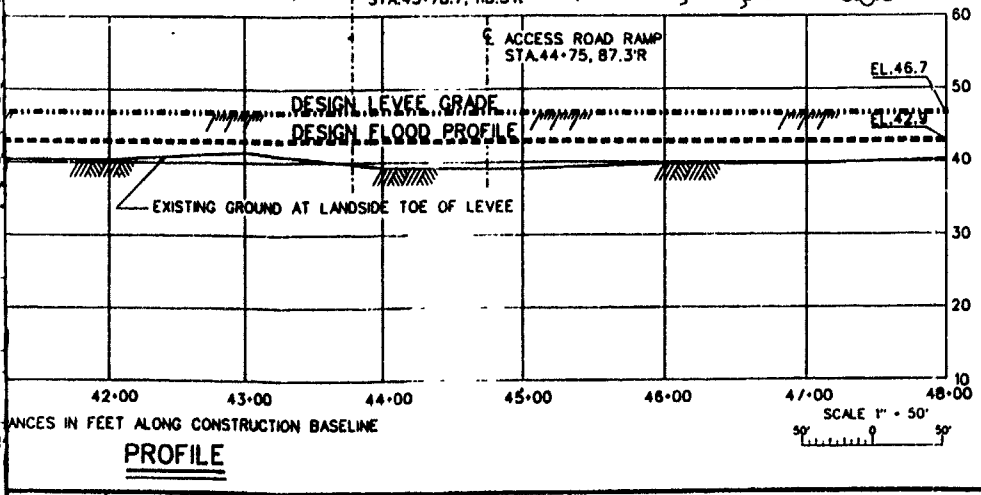

5
4
3
D
C
B
A
N
MATCH LINE STA.24+00
C.R.I. & P. R.R.
CONSTRUCTION BASELINE
STA.25+00
STA.30+20
WDM-89-83
WDM-65-45
IV ON 3H
36"SAN
10 IOWA CONCRETE PRODUCTS
4" STORM INTAKE TO BE REMOVED
IOWA CONCRETE PRODUCTS CO.
TANK
PILE
PLAN
WEST DES MOINES CITY DATUM
EL.47.5
EL.43.5
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
60
50
40
30
20
10
24+00
25+00
26+00
27+00
28+00
29+00
30+00
31+00
32+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE
(A)


3
2
1
D
C
B
A
OFFSET TABLE
STATION
℄ OFFSET
LEFT
RIGHT
REMARKS
18+78.3
72'
38+34.8
72'
C.R.I. & P.R.R.
MATCH LINE STA.36+00
STA.30+00
STA.35+00
HD IOWA CONCRETE PRODUCTS
4' STORM INTAKE TO BE REMOVED
WDM-89-82
4" WATERLINE TO BE RELOCATED
CONCRETE PRODUCTS CO.
PLAN
REFERENCES:
1 FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2 FOR TYPICAL SECTIONS, SEE PLATE 23
3 FOR LOGS OF BORINGS, SEE PLATE 29
4. FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EL.47.1
EL.43.1
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
30+00
31+00
32+00
33+00
34+00
35+00
36+00
CES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE
SCALE: 1" = 50'
Revisions
Symbol
Description
Date
Approved
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS
Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION
PLAN AND PROFILE
STA.24+00 TO STA.38+00
Scale: AS SHOWN
Date:
Drawing Code:
Sheet reference number:
Solicitation Number:
Sheet of
PLATE 6
(B)


5
4
3
D
C
B
A
MATCH LINE STA.36+00
C.R.I. & P. R.R.
CONSTRUCTION BASELINE
BURIED TEL CABLE
TEL CABLE GOES UNDERGROUND
GUY POLE
BURIED TEL BOX
WDM-65-44
WDM-89-81
VERT. RAIL
RAMP
F.H.
IV ON 3H
ROADS TO BE RELOCATED. ROAD TO BE REMOVED WITHIN LIMITS OF AND 15' BEYOND LEVEE TOE
CONC SLAB
VALVE
SCALE
BLDG
FOUNDATIONS
NEW GATEWELL C, SEE PLATE 35
CLOSURE STRUCTURE, SEE PLATE 40.
WALL
TANK
NEW LEVEE
DISTURBED AREAS
MARTIN-MARIETTA SPUR TRACK
1144'R CURVE
576'R CURVE
348'R CURVE
220'R CURVE
75'R CURVE
TOE RAMP
EXIST TWIN 60" R.C.P. CULVERT
GATE
PILE
PLAN
℄ NEW GATEWELL C
STA 43+78.7, 118.5'R
℄ CLOSURE STRUCTURE
STA.39+33.5
35'
EL.47.1
EL.47.0
EL.43.1
EL.43.0
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
WEST DES MOINES CITY DATUM
60
50
40
30
20
10
36+00
37+00
38+00
39+00
40+00
41+00
42+00
43+00
44+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE

(A)





OFFSET TABLE

STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
10+78.3		72'	
38+39.0		72'	
40+86.8		248.8'	P.I. 75'R CURVE
42+20.1		142.7'	
45+53.9		70'	
54+92.6		70'	

REFERENCES:

1 FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2 FOR TYPICAL SECTIONS, SEE PLATE 23
3. FOR LOGS OF BORINGS, SEE PLATE 29
4 FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51.

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Revised by:
Approved by: (Chief, Engrg. Div., CORPS OF ENGRS)

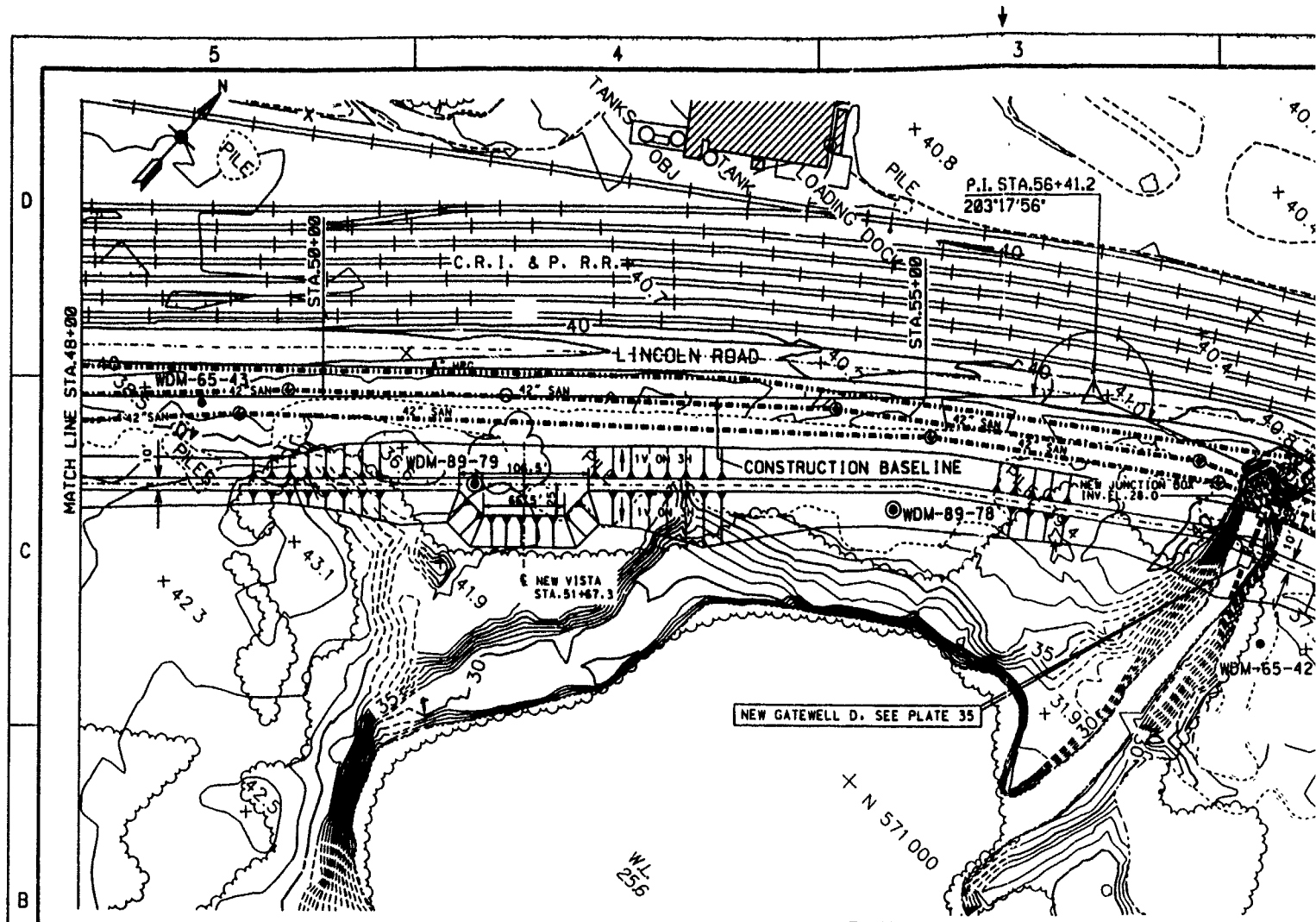
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PLAN AND PROFILE
STA.38+00 TO STA.48+00

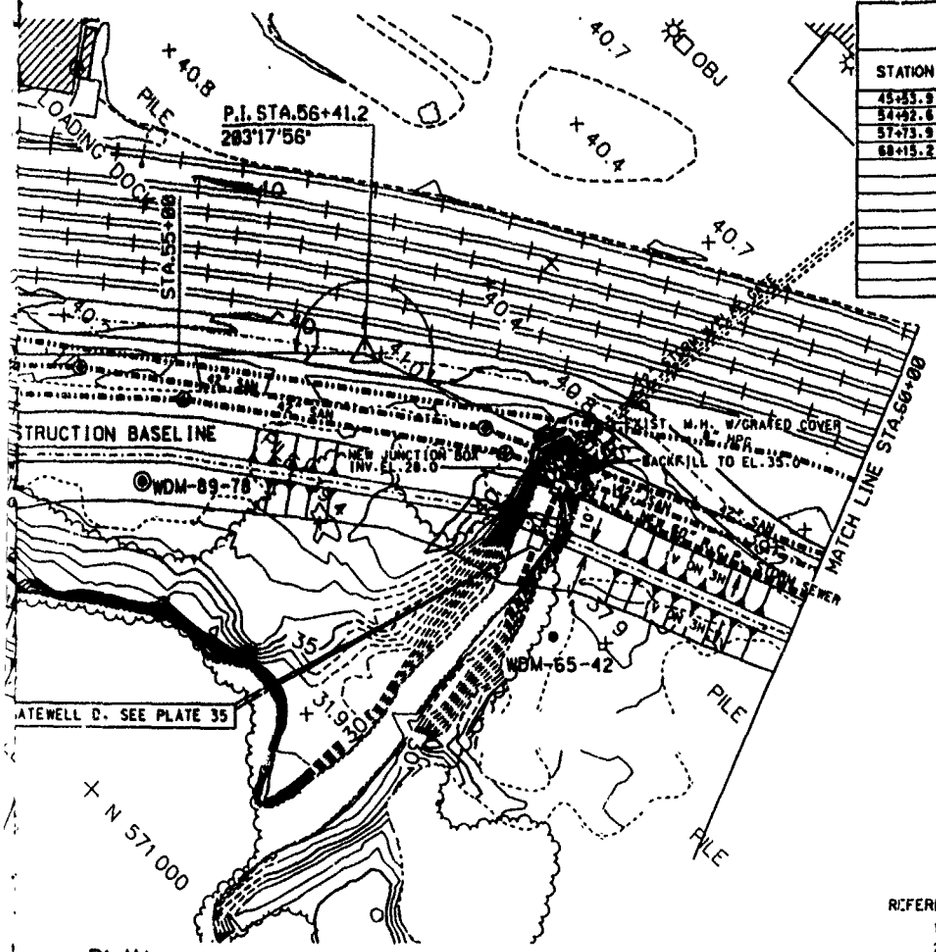
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Drawing Code:
Sheet reference number:
Solicitation Number:
Sheet of

PLATE 7

(B)


N
TANKS
OBJ
TANK
LOADING DOCK
PILE
P.I. STA.56+41.2
203°17'56"
C.R.I. & P. R.R.
LINCOLN ROAD
STA.50+00
STA.55+00
MATCH LINE STA.48+00
WDM-65-43
WDM-89-79
WDM-89-78
WDM-65-42
CONSTRUCTION BASELINE
1V ON 3H
NEW JUNCTION BOX
INV. EL. 28.0
℄ NEW VISTA
STA. 51+67.3
NEW GATEWELL D. SEE PLATE 35
N 571000
W.L. 256
42" SAN
8" WPC
PLAN
EL. 46.7
EL. 42.9
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
WEST DES MOINES CITY DATUM
60
50
40
30
20
10
48+00
49+00
50+00
51+00
52+00
53+00
54+00
55+00
56+00
57+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE

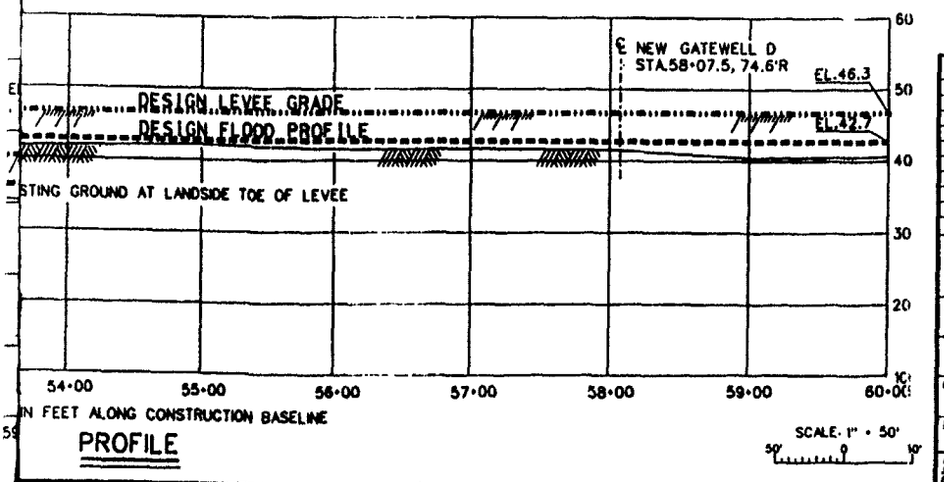
(A)



PLAN

OFFSET TABLE

STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
45+55.9		70'	
54+92.6		70'	
57+73.9		80.5'	P.I. 75'R CURVE
68+15.2	0	0	



PROFILE

SCALE: 1" = 50'

REFERENCES:

1 FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2 FOR TYPICAL SECTIONS, SEE PLATE 23.
3 FOR LOGS OF BORINGS, SEE PLATE 29
4 FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

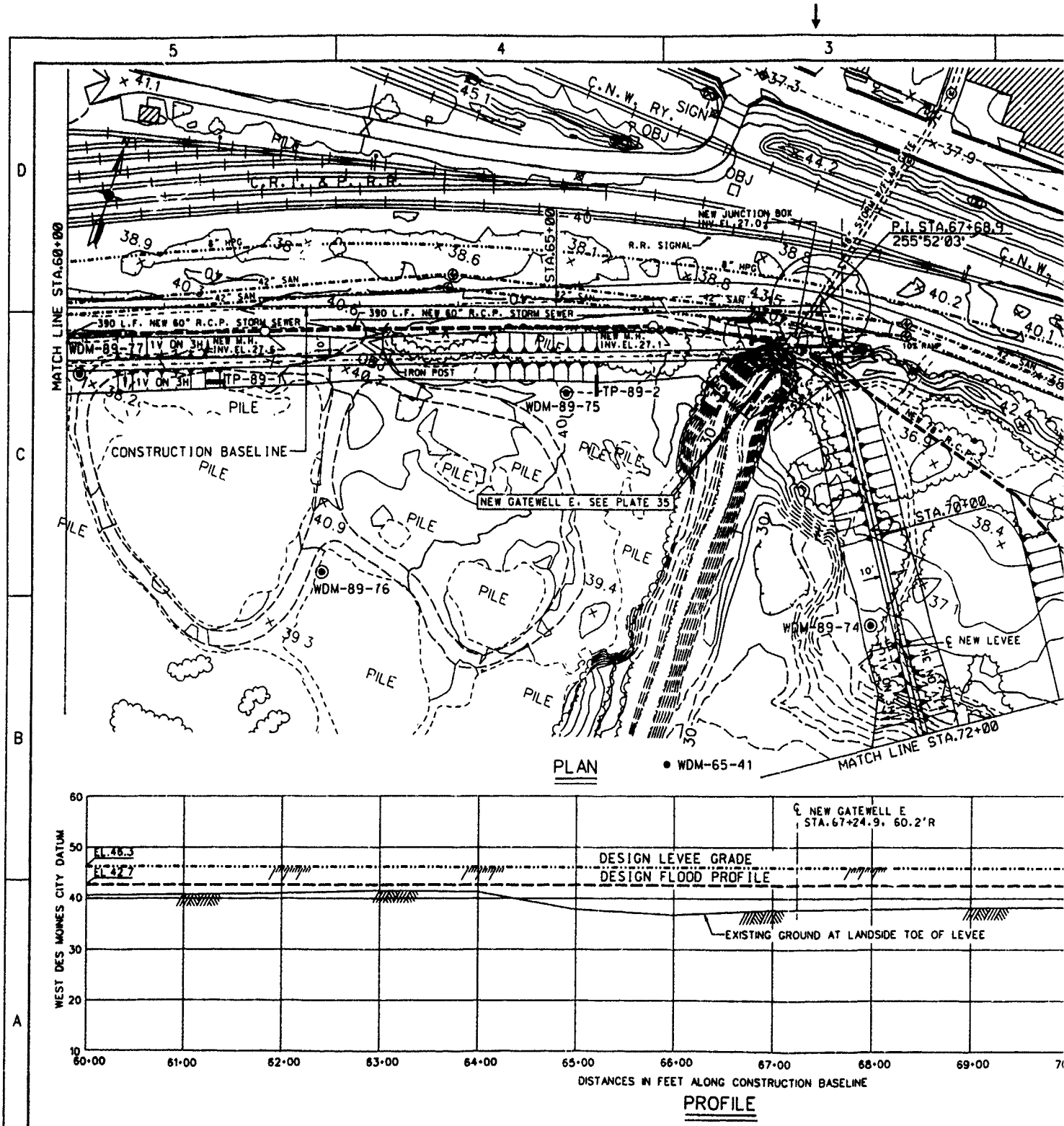
PLAN AND PROFILE
STA.48+00 TO STA.60+00

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:
CHIEF, ENGINEERING DIV., CORPS OF ENGINEERS

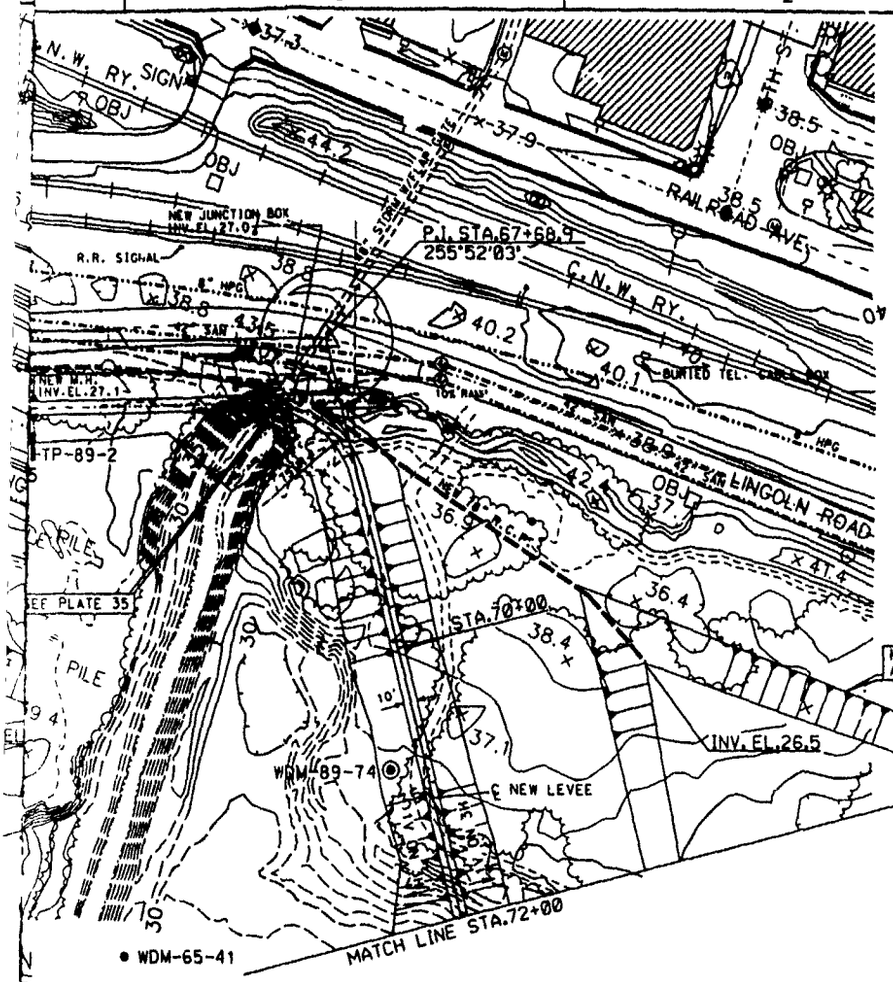
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Drawing Code:
Sheet reference number:
Solicitation Number:
Sheet of

PLATE 8

(B)


5
4
3
D
C
B
A
MATCH LINE STA.60+00
C.N.W. RY. SIGN
R.OBJ
C.R.I. & P.R.R.
NEW JUNCTION BOX INV. EL. 27.0
P.I. STA.67+68.9
255°52'03"
C.N.W.
R.R. SIGNAL
390 L.F. NEW 60" R.C.P. STORM SEWER
WDM-89-77
1V ON 3H
NEW M.H. INV. EL. 27.6
NEW M.H. INV. EL. 27.1
IRON POST
TP-89-1
TP-89-2
WDM-89-75
PILE
CONSTRUCTION BASELINE
NEW GATEWELL E, SEE PLATE 35
WDM-89-16
WDM-89-74
℄ NEW LEVEE
STA.70+00
MATCH LINE STA.72+00
PLAN
• WDM-65-41
WEST DES MOINES CITY DATUM
EL.46.3
EL.42.7
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
℄ NEW GATEWELL E
STA.67+24.9, 60.2'R
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
60+00
61+00
62+00
63+00
64+00
65+00
66+00
67+00
68+00
69+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE

(A)

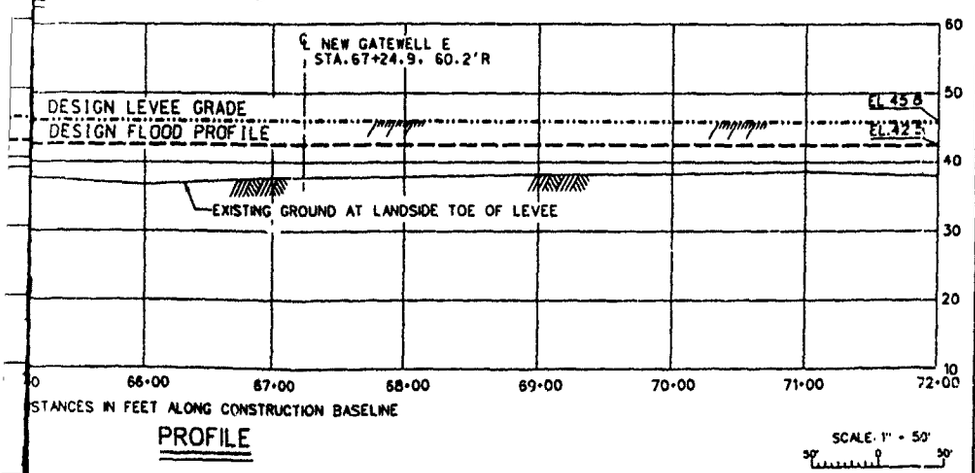


OFFSET TABLE

STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
57+73.9		60.5'	P.I. 75'R CURVE
68+15.2	0	0	
78+41.5	0	0	

REFERENCES:

1 FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2 FOR TYPICAL SECTIONS, SEE PLATE 23
3 FOR LOGS OF BORINGS, SEE PLATE 30
4 FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51



Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by: JOHN R. BROWN, COL., CORPS OF ENGINEERS

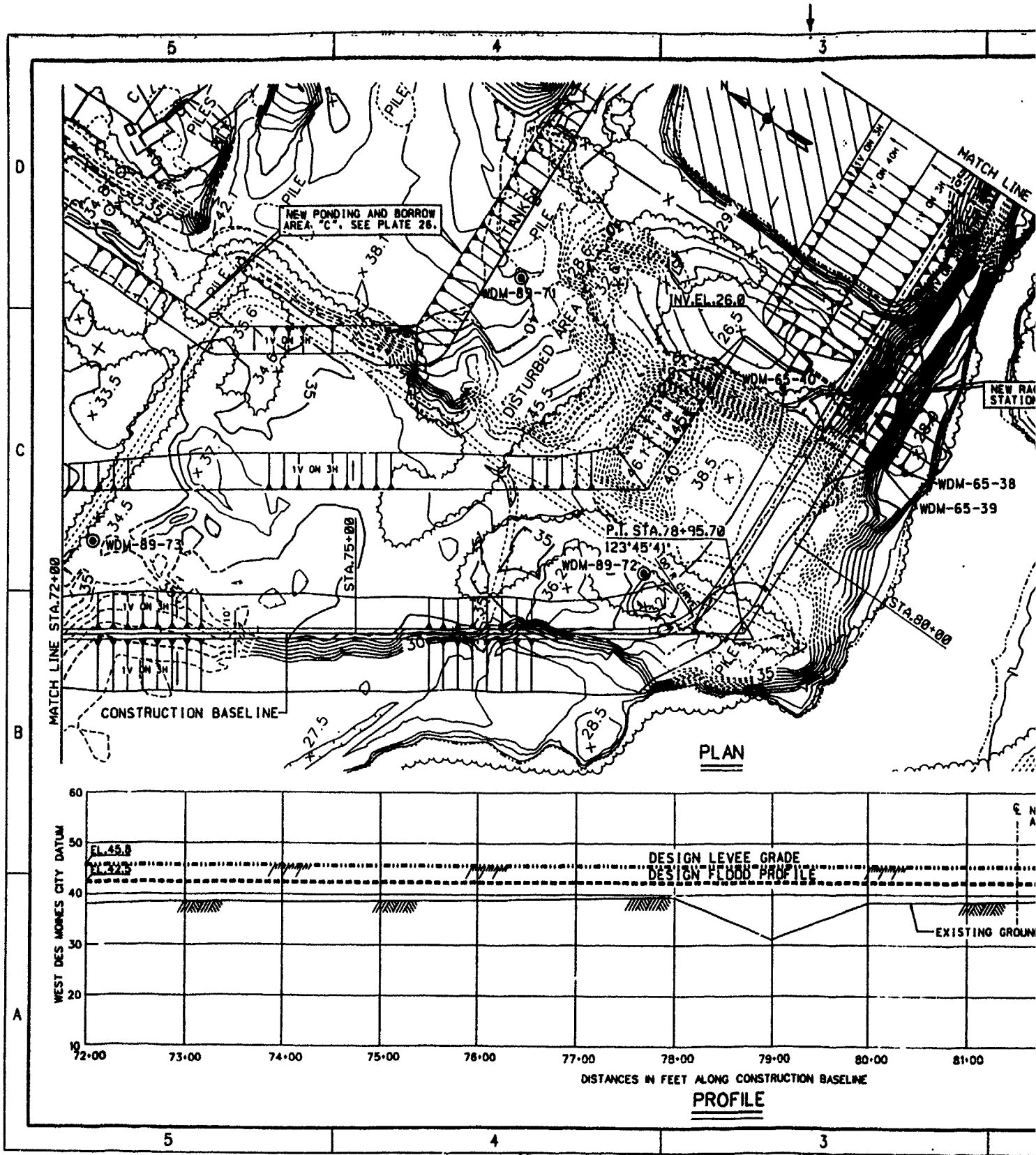
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PLAN AND PROFILE
STA.60+00 TO STA.72+00

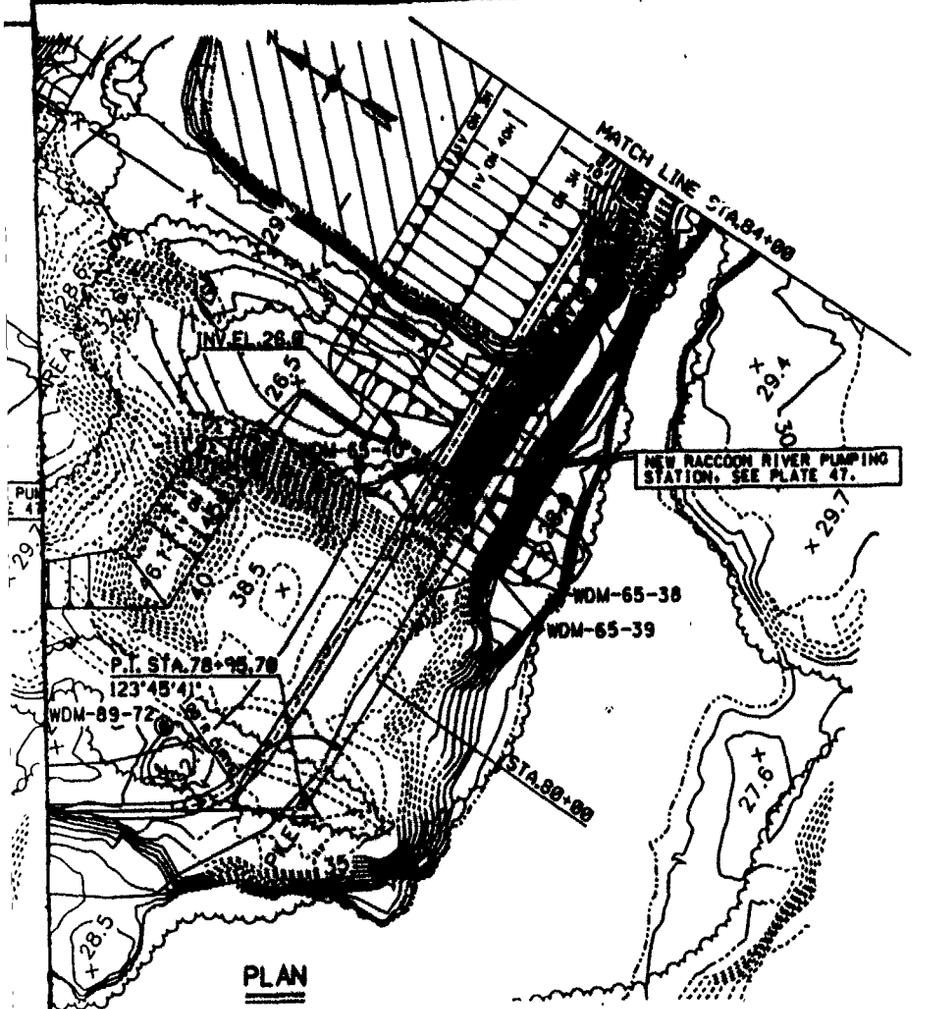
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Solicitation Number:
Sheet of

PLATE 9

(B)


5
4
3
D
C
B
A
MATCH LINE
NEW PONDING AND BORROW AREA "C". SEE PLATE 26.
WDM-89-71
INV.EL.26.0
DISTURBED AREA
WDM-65-40
WDM-65-38
WDM-65-39
WDM-89-73
WDM-89-72
P.I. STA.78+95.70
123°45'41"
STA.75+00
STA.80+00
MATCH LINE STA.72+00
CONSTRUCTION BASELINE
PILES
PILE
TANK Bd
1V ON 3H
PLAN
WEST DES MOINES CITY DATUM
EL.45.0
EL.42.5
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EXISTING GROUND
72+00
73+00
74+00
75+00
76+00
77+00
78+00
79+00
80+00
81+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE

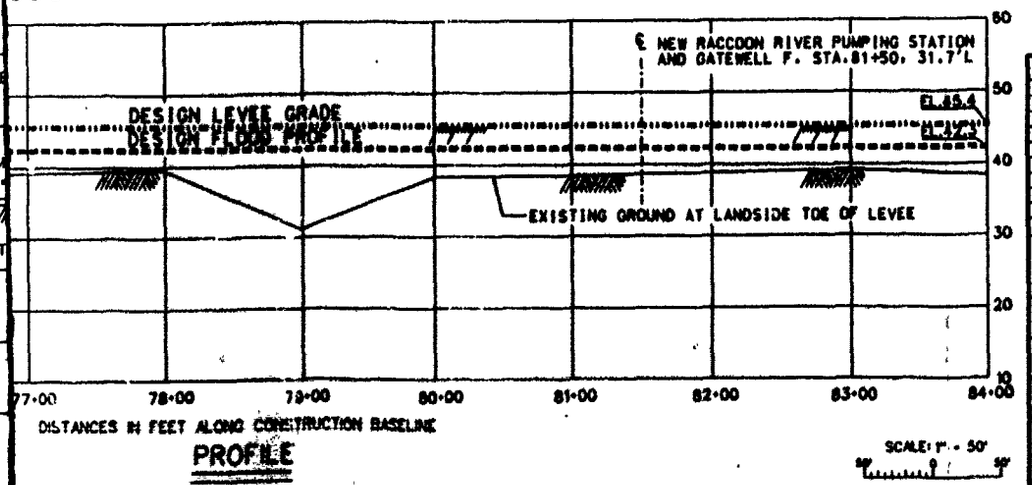
(A)



OFFSET TABLE			
STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
80+15.2	0	0	
78+41.5	0	0	P.I. 100'R CURVE
85+00.0	45'		

REFERENCES:

1. FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1.
2. FOR TYPICAL SECTIONS, SEE PLATE 23.
3. FOR LOGS OF BORINGS, SEE PLATE 30
4. FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51.



Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

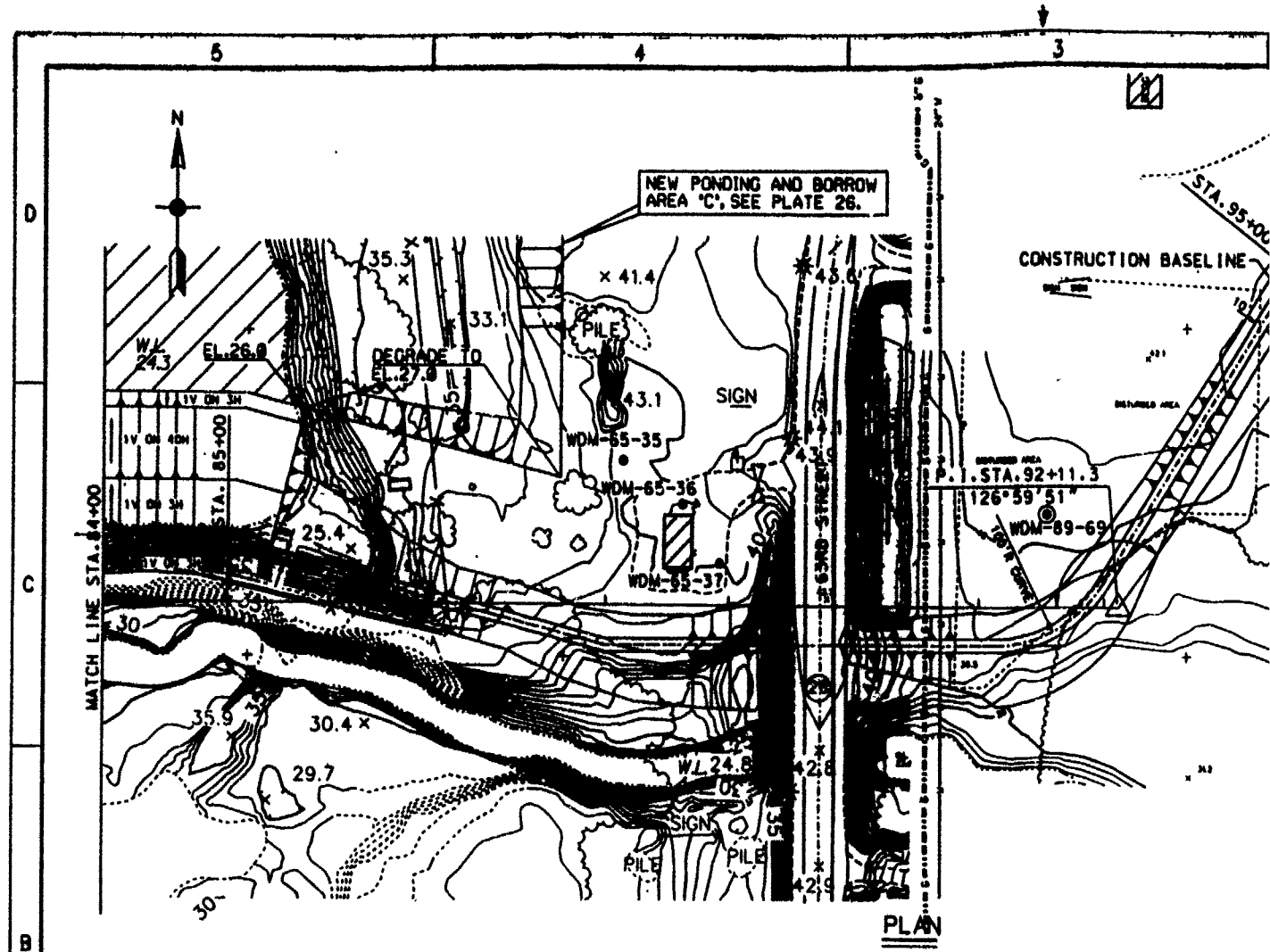
Designed by
Drawn by
Checked by
Revised by
Approved by

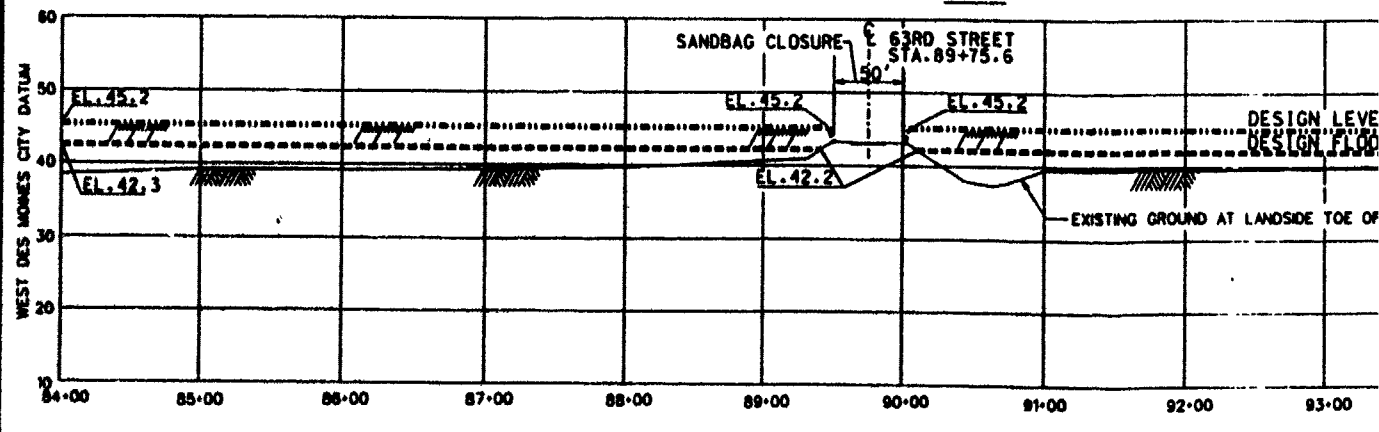
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PLAN AND PROFILE
STA.72+00 TO STA.84+00

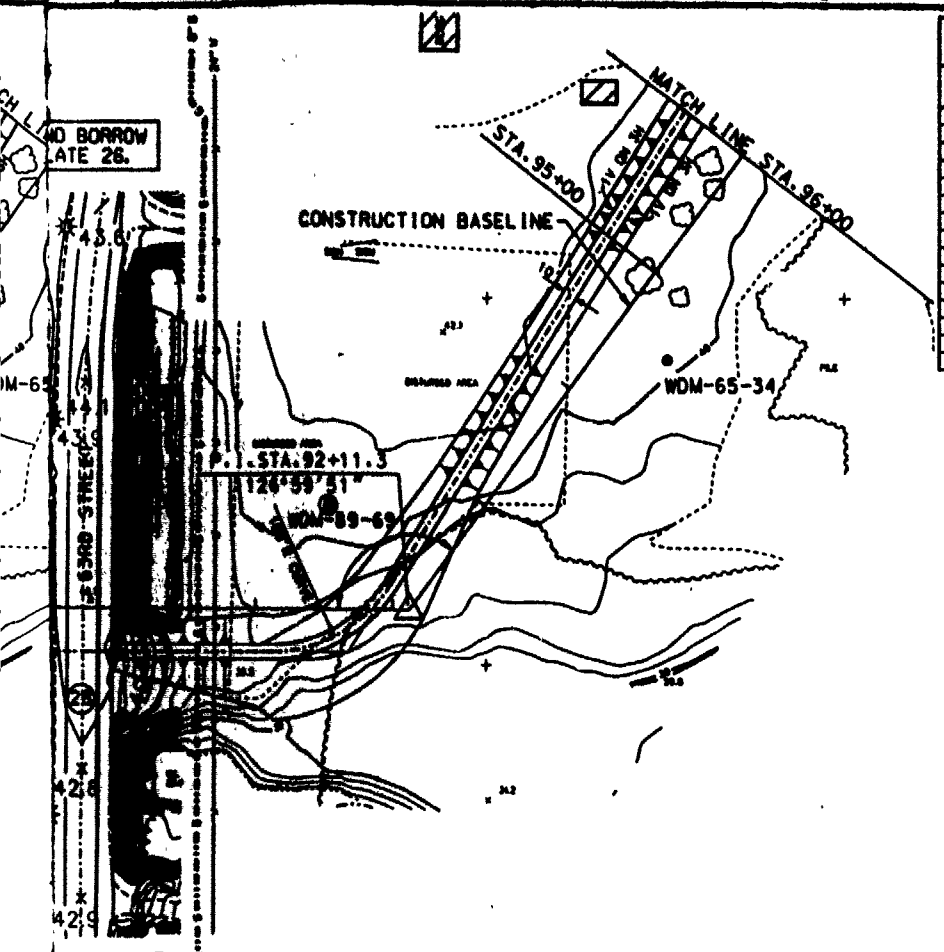
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PLATE 10


NEW PONDING AND BORROW AREA 'C', SEE PLATE 26.
CONSTRUCTION BASELINE
STA. 95+00
P.I. STA. 92+11.3
126°59'51"
WDM-89-69
WDM-65-35
WDM-65-36
WDM-65-37
SIGN
PILE
DEGRADE TO EL. 27.8
EL. 26.8
W.L. 24.3
63RD STREET
MATCH LINE STA. 84+00
STA. 85+00
1V ON 3H
1V ON 4DH
35.3
33.1
41.4
43.6
43.1
25.4
30.4
29.7
35.9
42.8
42.9
PLAN


SANDBAG CLOSURE
℄ 63RD STREET STA. 89+75.6
50'
EL. 45.2
EL. 42.3
EL. 42.2
DESIGN LEVE
DESIGN FLOO
EXISTING GROUND AT LANDSIDE TOE OF
WEST DES MOINES CITY DATUM
60
50
40
30
20
10
84+00
85+00
86+00
87+00
88+00
89+00
90+00
91+00
92+00
93+00
PROFILE

(A)

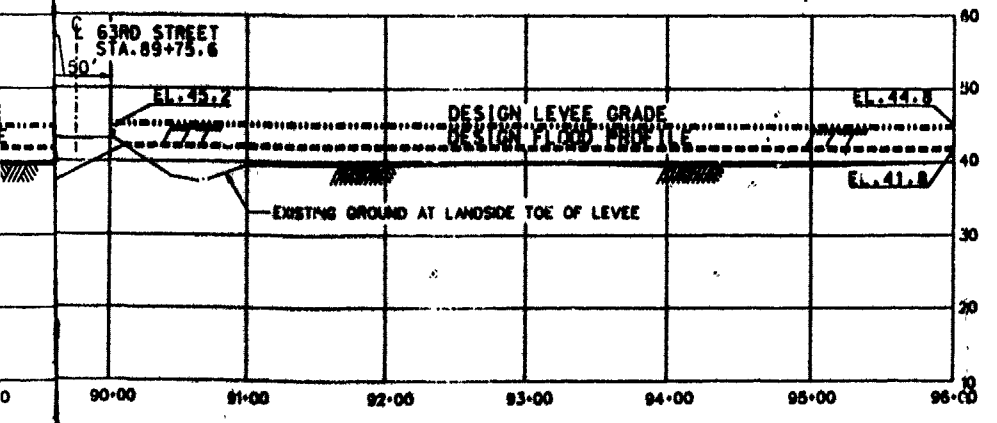


OFFSET TABLE

STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
[illegible]+41.5	0	0	P.I. 100'R CURVE
[illegible]+85.6	48.6'		
97+84.3		36.8'	
91+40.0		29.1'	P.I. 100'R CURVE
108+89.1	95.7'		

REFERENCES:

1. FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1.
2. FOR TYPICAL SECTIONS, SEE PLATE 23.
3. FOR LOGS OF BORINGS, SEE PLATE 30.
4. FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51.



SCALE: 1" = 50'

Symbol	Revisions Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:

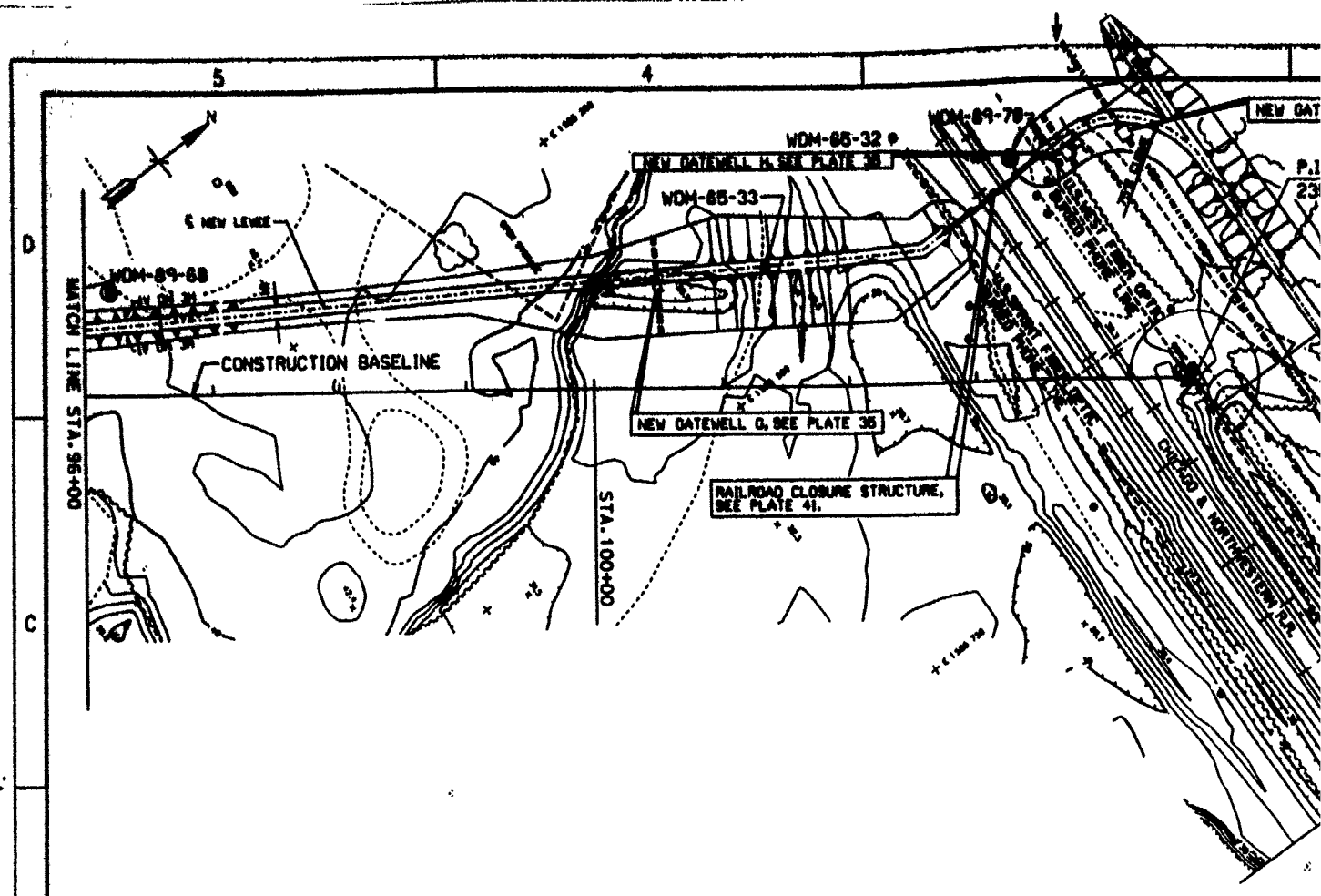
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PLAN AND PROFILE
STA. 84+00 TO STA. 98+00

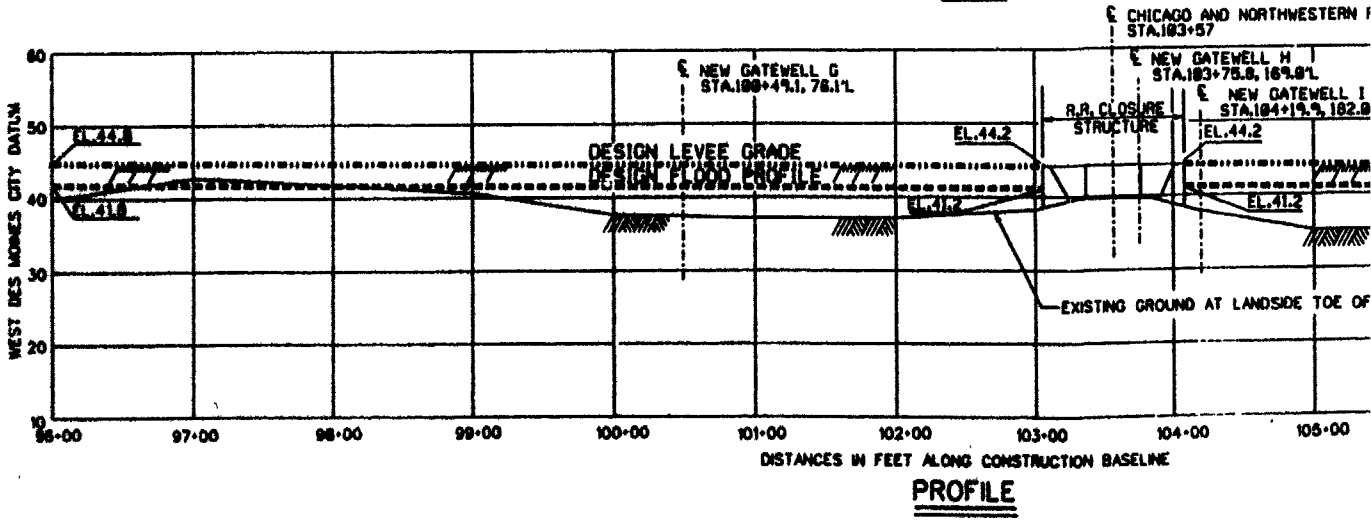
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PLATE 11

(B)

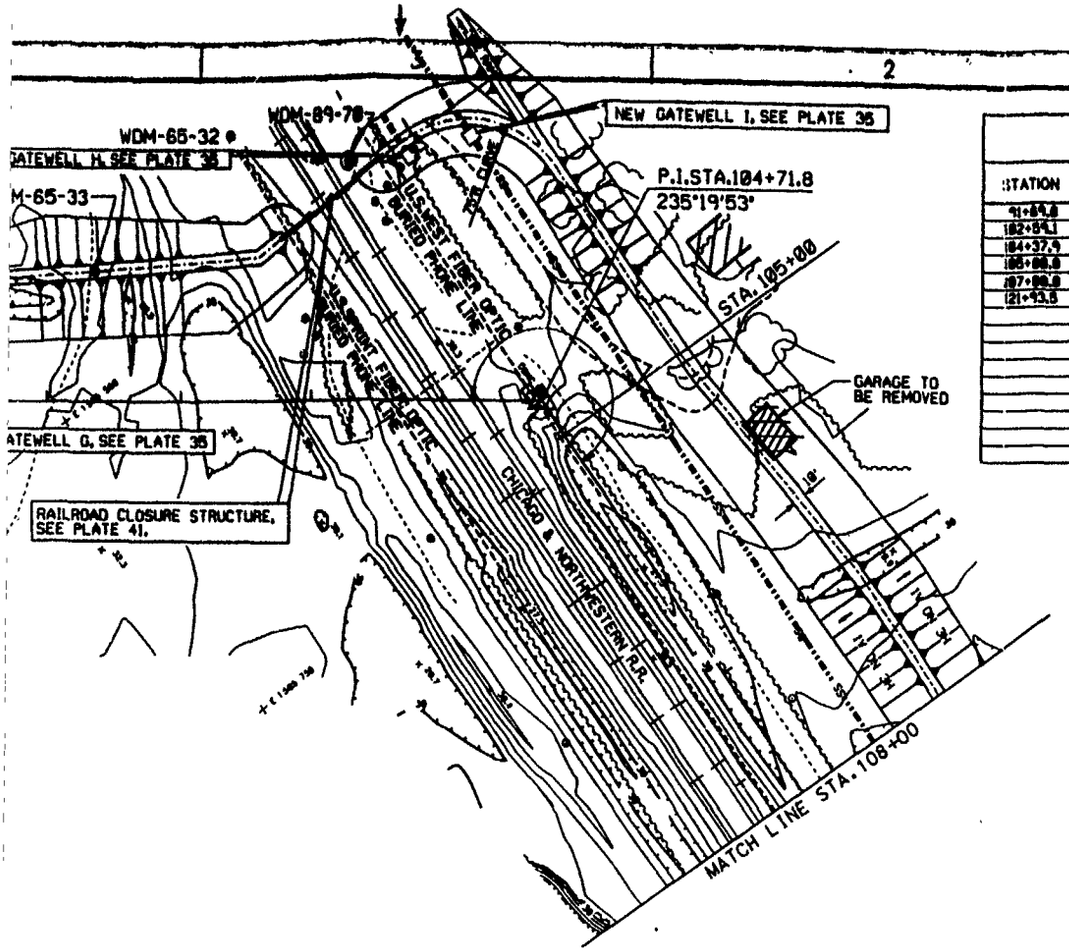


PLAN



PROFILE

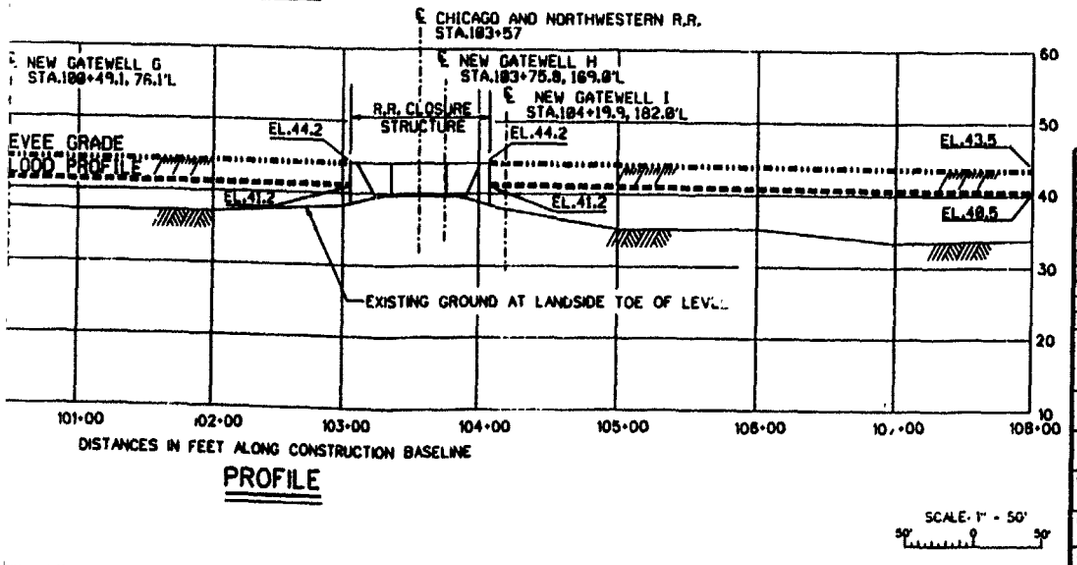
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OFFSET TABLE

STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
91+84.8		34.1'	P.I. OF 100'R CURVE
102+84.1	99.7'		
104+37.9	223.8'		
105+88.8	99.7'		
107+89.8	119.8'		
121+93.8	0	0	P.I. OF 100'R CURVE

PLAN



PROFILE

SCALE: 1" = 50'

REFERENCES:

1. FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2. FOR TYPICAL SECTIONS, SEE PLATE 23
3. FOR LOGS OF BORINGS, SEE PLATE 31
4. FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:

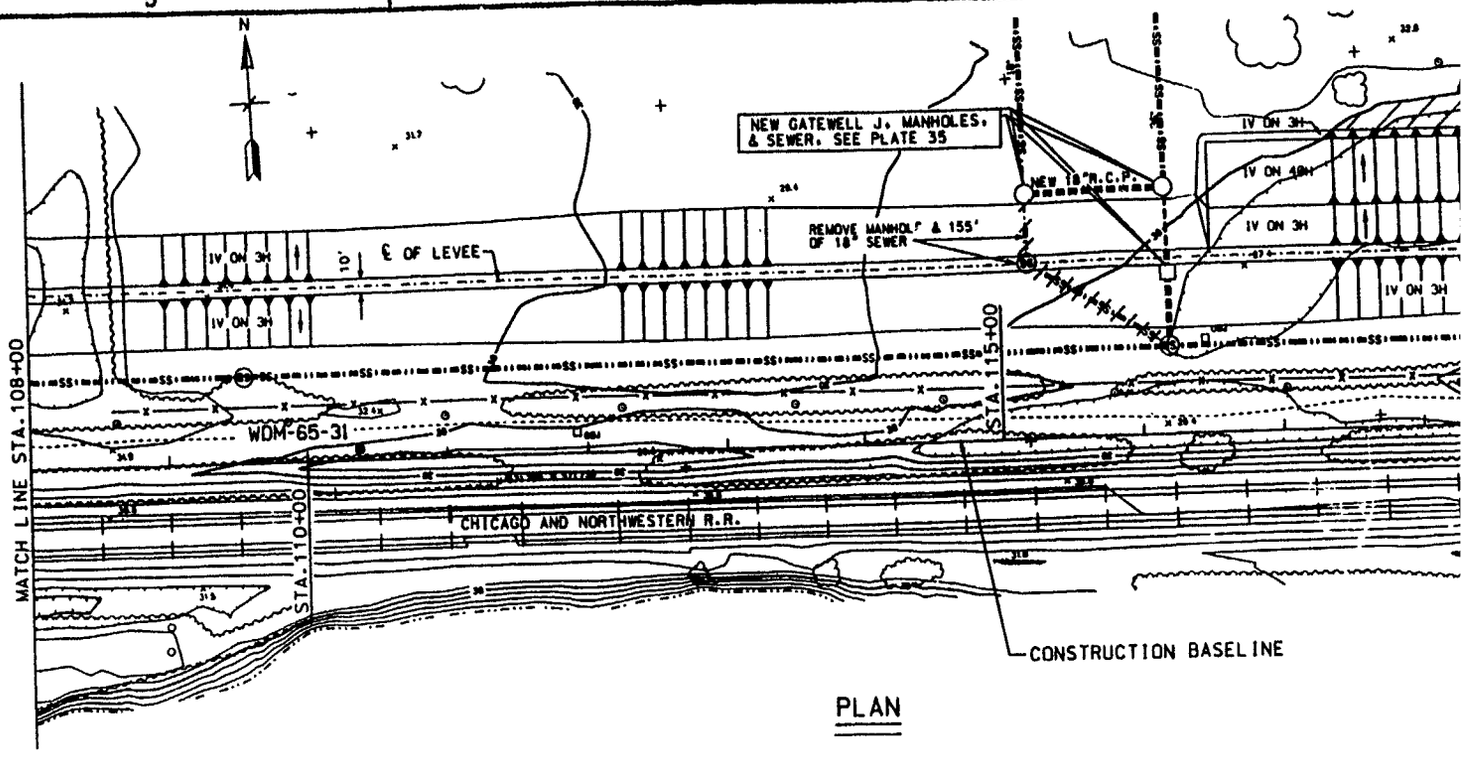
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PLAN AND PROFILE
STA.98+00 TO STA.108+00

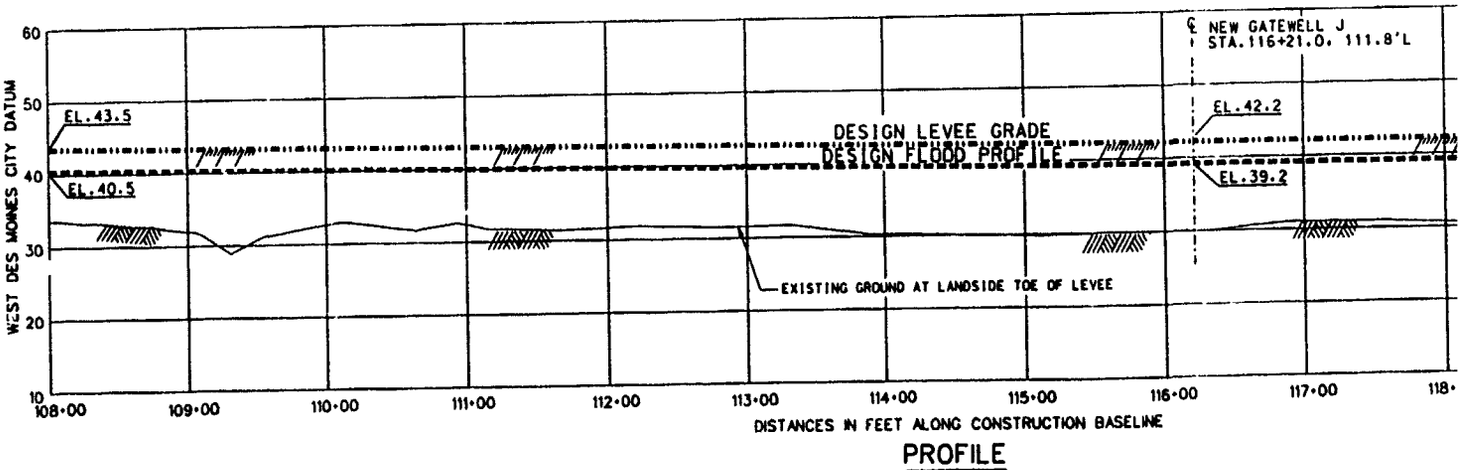
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Sheet reference number:
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PLATE 12

(B)



PLAN

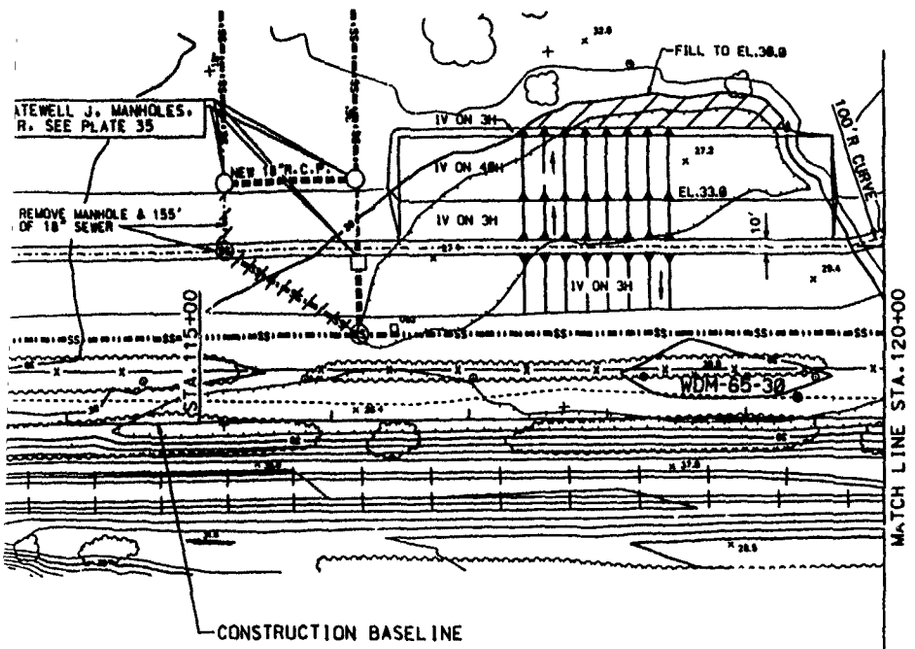


PROFILE

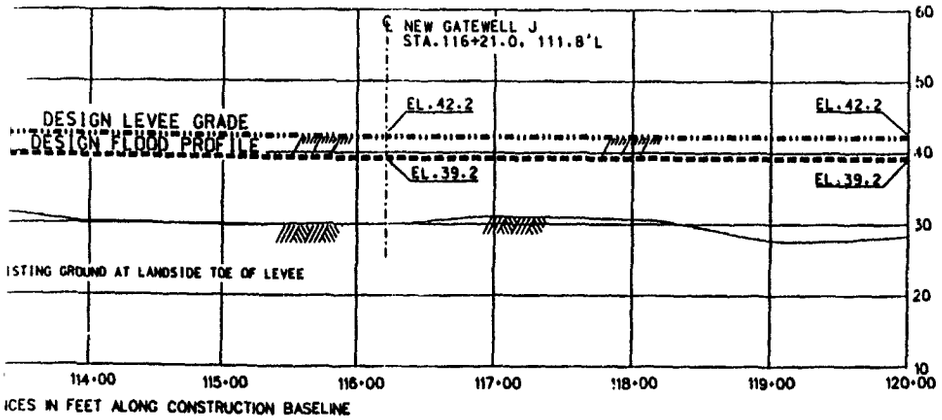
OFFSET TABLE

STATION	℄ OFFSET		REMARKS
	LEFT	RIGHT	
107+00.0	119.8'		
121+93.5	0	0	P.I. OF 100'R CURVE

(A)



PLAN



PROFILE

REFERENCES:

1 FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2 FOR TYPICAL SECTIONS, SEE PLATE 23
3 FOR LOGS OF BORINGS, SEE PLATE 31
4 FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51

NOTE:

BORINGS NO. WDM-65-23, 24, 25, 26, 27, 28 & 29 ARE NOT SHOWN; THEY ARE LOCATED OUTSIDE OF THE CURRENT PROJECT PARAMETERS.

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Revised by:
Approved by:

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PLAN AND PROFILE
STA.108+00 to STA.120+00

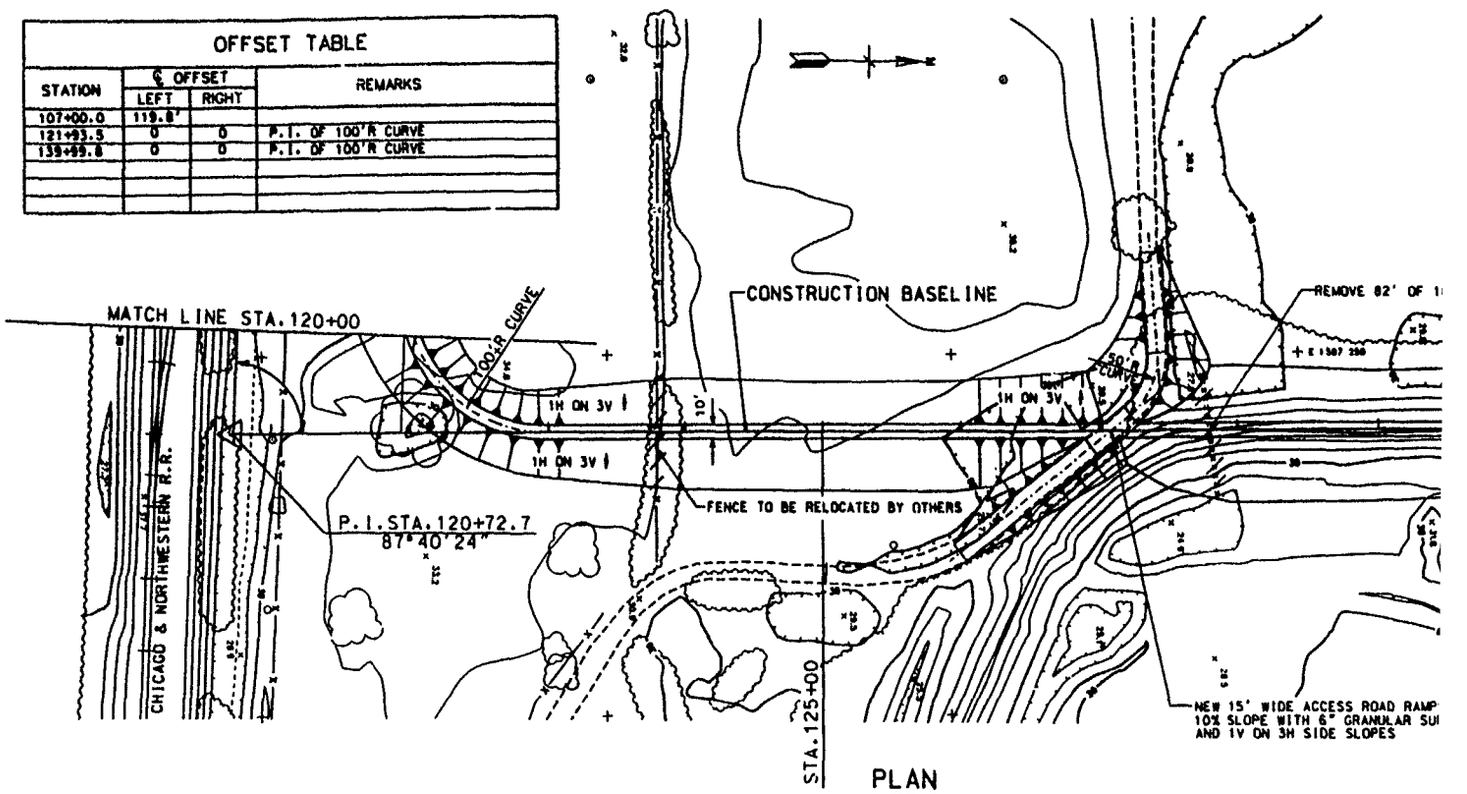
SCALE: 1" = 50'

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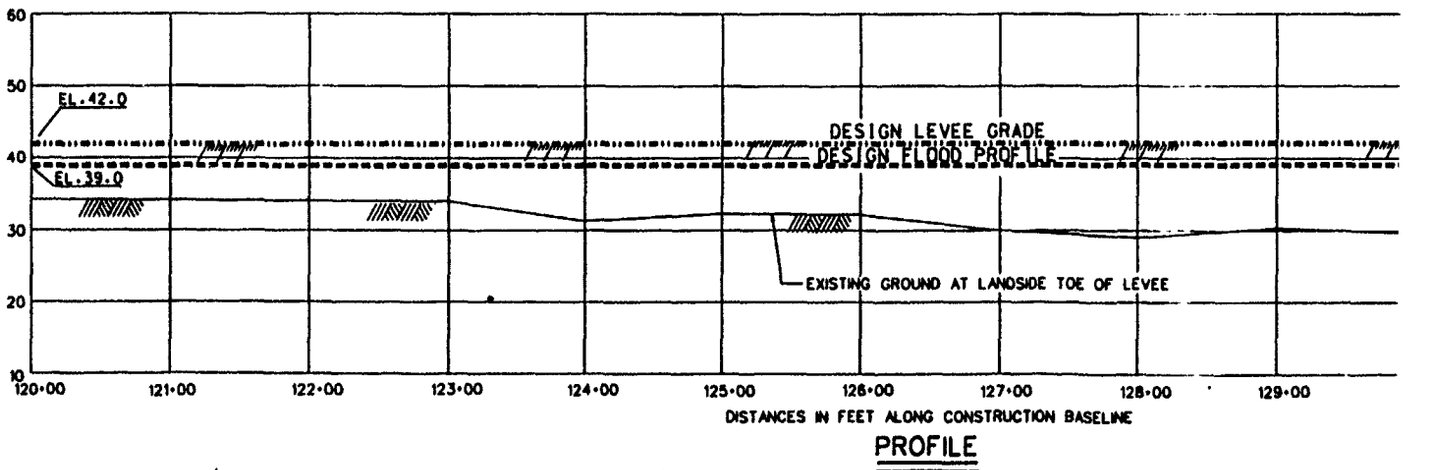
PLATE 13

(B)

OFFSET TABLE			
STATION	℄ OFFSET		REMARKS
	LEFT	RIGHT	
107+00.0	119.8'		
121+93.5	0	0	P.I. OF 100'R CURVE
139+99.8	0	0	P.I. OF 100'R CURVE

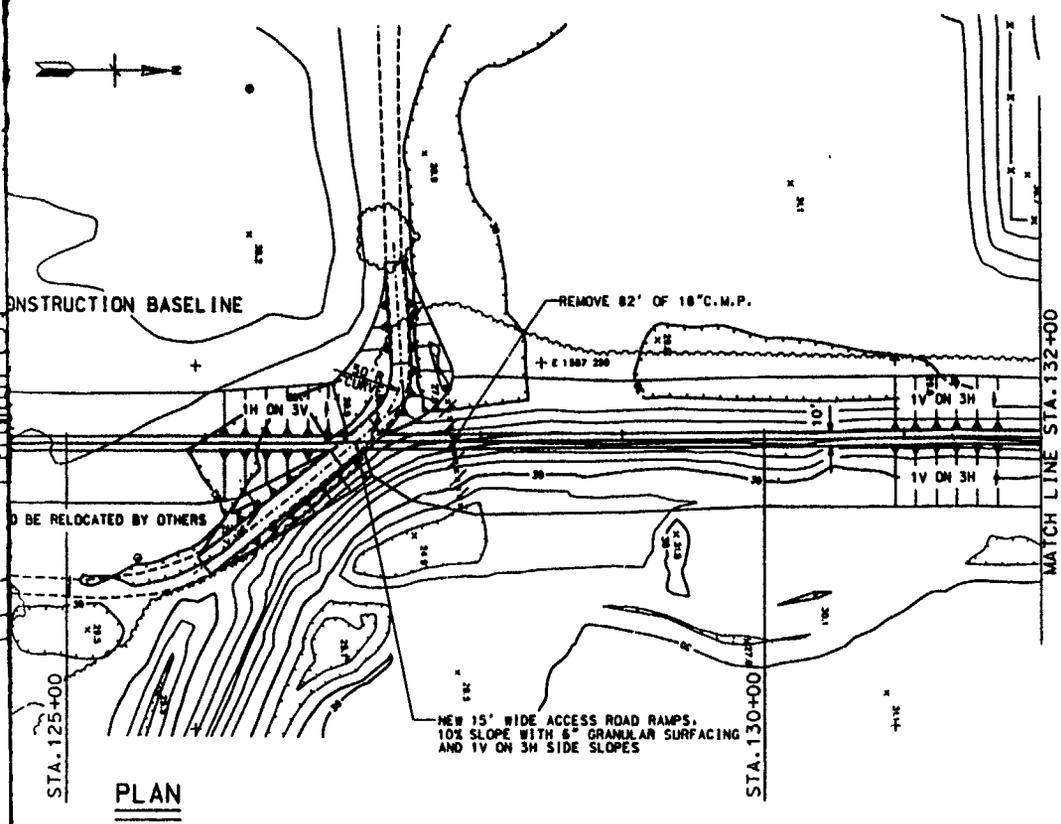


PLAN



PROFILE

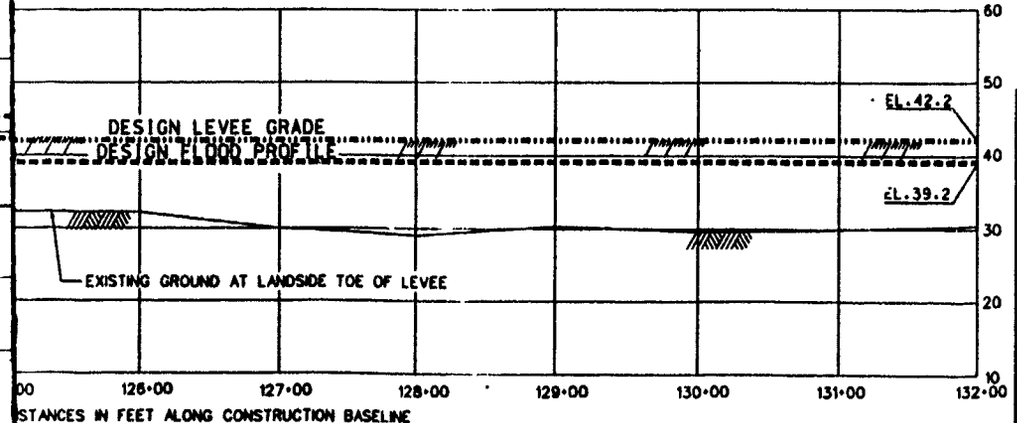
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PLAN

REFERENCES:

1 FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2 FOR TYPICAL SECTIONS, SEE PLATE 23
3 FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51.



PROFILE

SCALE: 1" = 50'

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

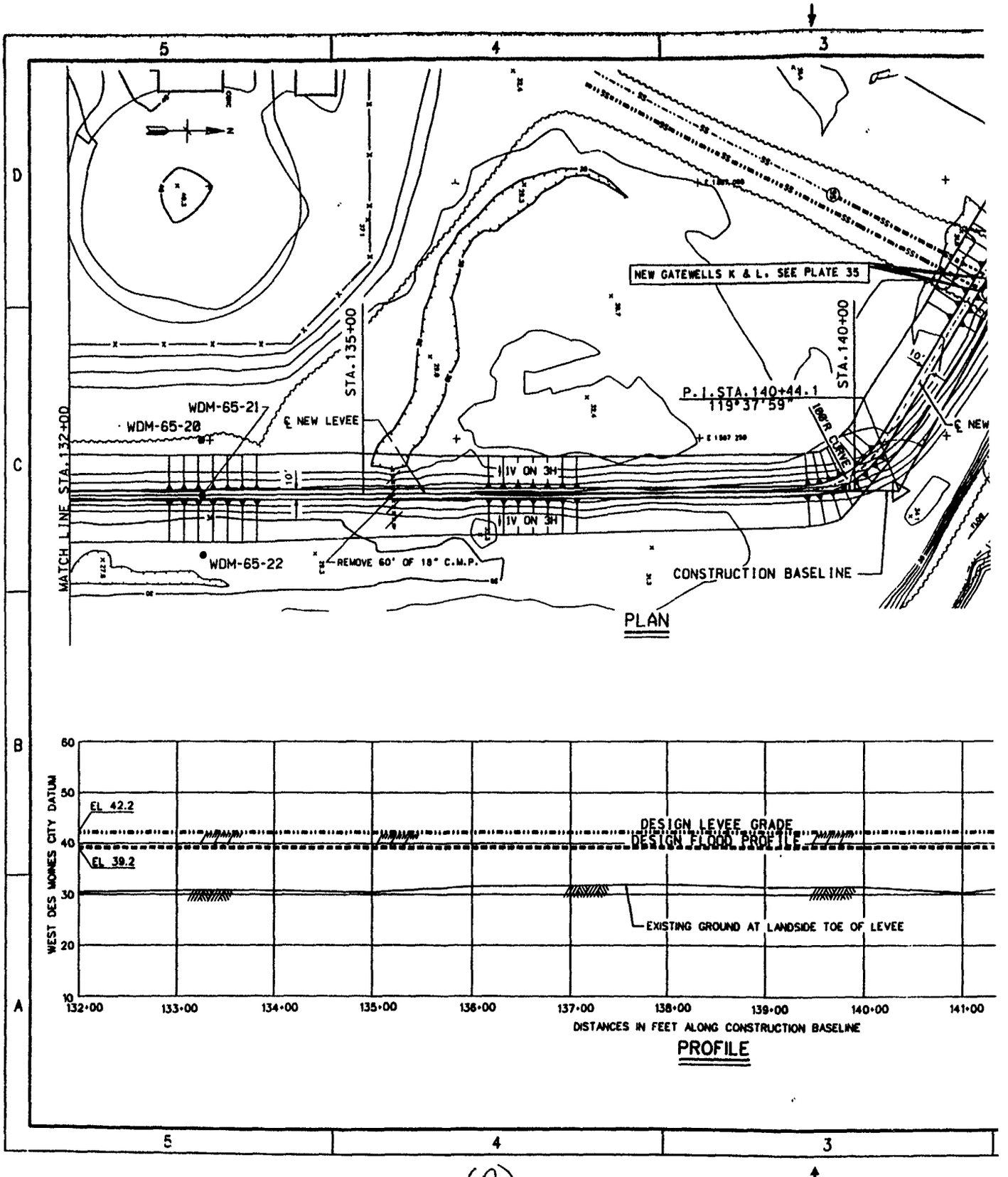
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PLAN AND PROFILE
STA.120+00 to STA.132+00

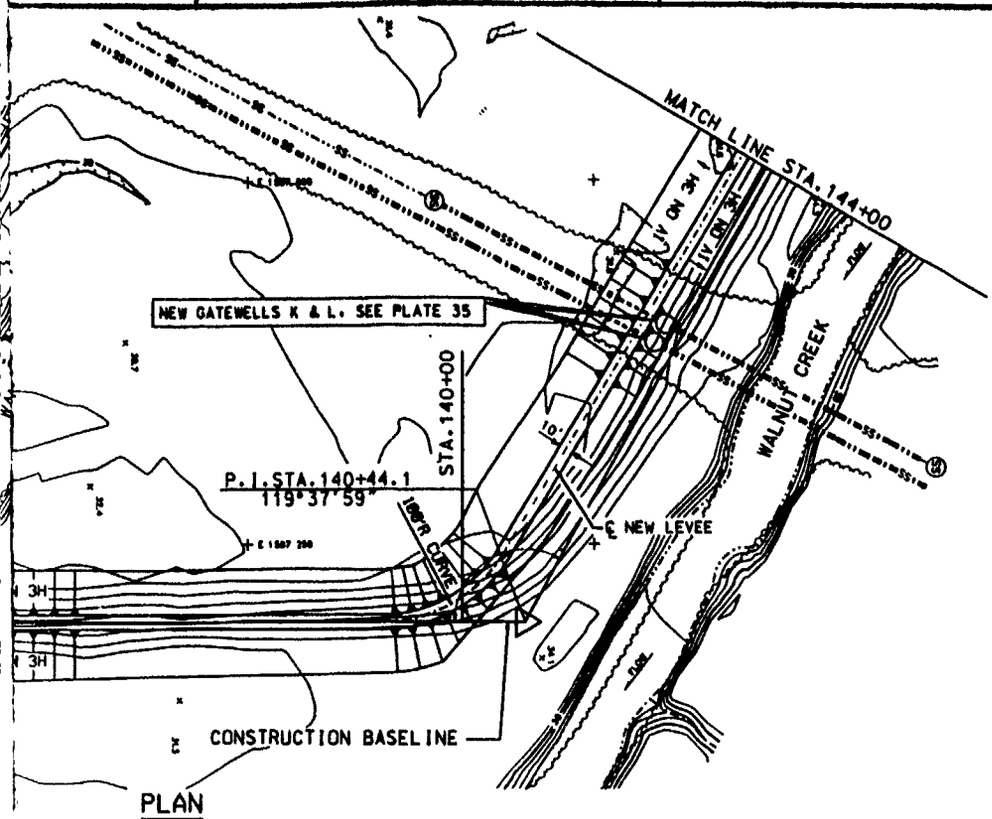
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Drawn by:			
Checked by:			
Revised by:	Scale: AS SHOWN	Sheet reference number:	Invitation Number:
Approved by:	Date:		
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PLATE 14

(B)

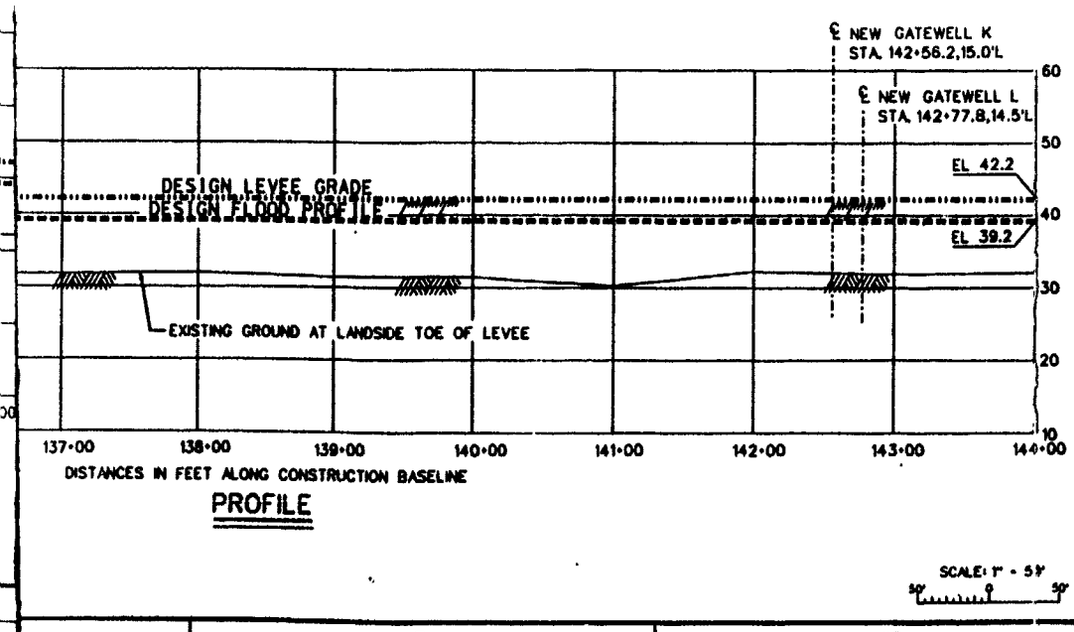

5
4
3
D
C
B
A
NEW GATEWELLS K & L. SEE PLATE 35
STA. 135+00
STA. 140+00
P.I. STA. 140+44.1
119°37'59"
WDM-65-21
WDM-65-20
℄ NEW LEVEE
MATCH LINE STA. 132+00
1V ON 3H
1V ON 3H
WDM-65-22
REMOVE 60' OF 18" C.M.P.
CONSTRUCTION BASELINE
PLAN
WEST DES MOINES CITY DATUM
60
50
40
30
20
10
EL 42.2
EL 39.2
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
132+00
133+00
134+00
135+00
136+00
137+00
138+00
139+00
140+00
141+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE

(A)



PLAN

OFFSET TABLE			
STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
121+93.5	0	0	P.I. OF 100'R CURVE
139+99.8	0	0	P.I. OF 100'R CURVE
145+08.6	19.6'		



PROFILE

SCALE: 1" = 50'

REFERENCES:

1. FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2. FOR TYPICAL SECTIONS, SEE PLATE 23
3. FOR LOGS OF BORINGS, SEE PLATE 31.
4. FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51.

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

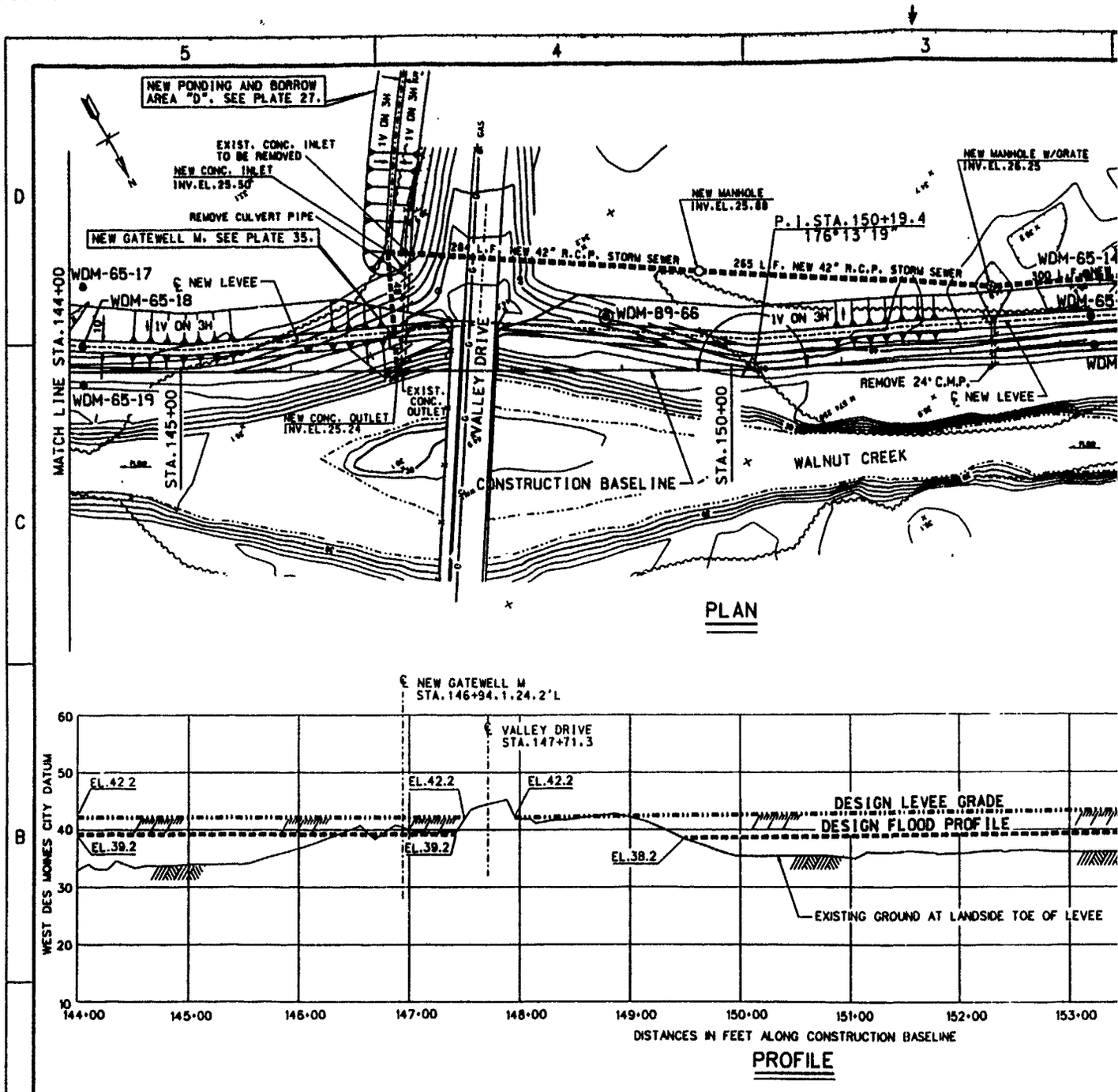
PLAN AND PROFILE
STA. 132+00 TO STA. 144+00

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:
Scale: AS SHOWN
Date:
Drawing Code:
Sheet reference number:
Invitation Number:
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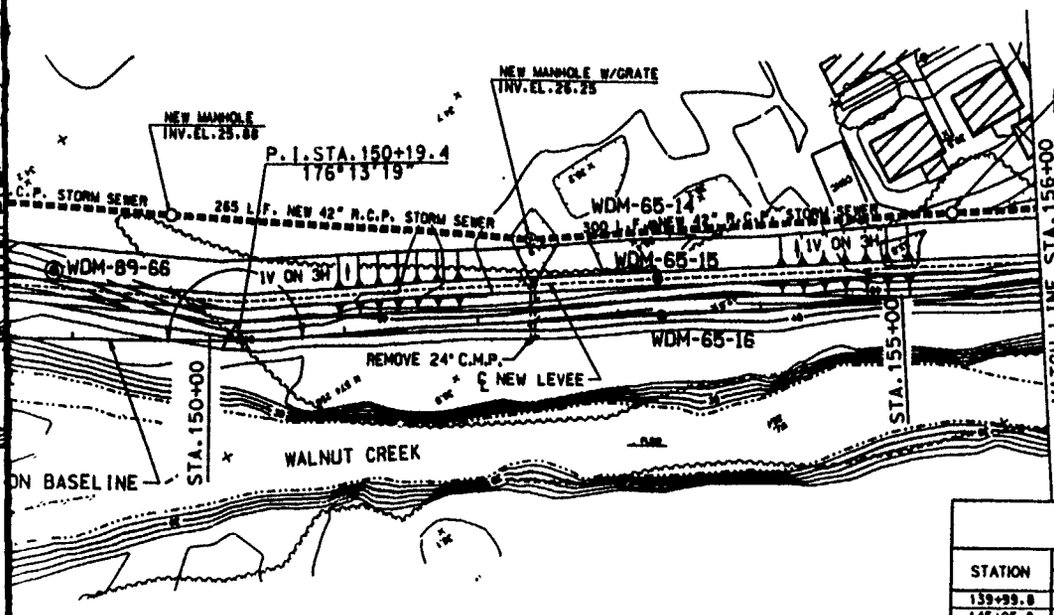
3 2 1

PLATE 15

(B)

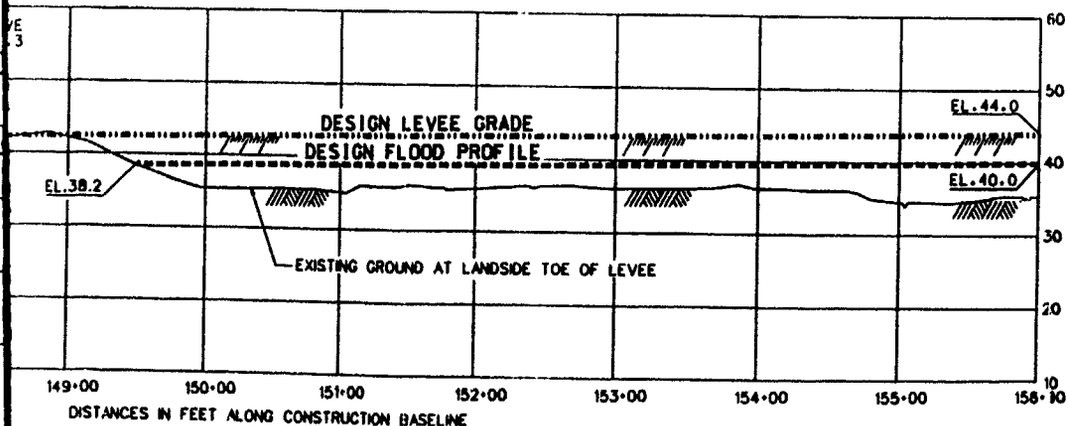

NEW PONDING AND BORROW AREA "D", SEE PLATE 27.
EXIST. CONC. INLET TO BE REMOVED
NEW CONC. INLET INV.EL.25.50
REMOVE CULVERT PIPE
NEW GATEWELL M, SEE PLATE 35.
NEW MANHOLE INV.EL.25.88
NEW MANHOLE W/GRATE INV.EL.26.25
P.I.STA.150+19.4 176°13'19"
284 L.F. NEW 42" R.C.P. STORM SEWER
265 L.F. NEW 42" R.C.P. STORM SEWER
WDM-65-17
WDM-65-18
WDM-65-19
WDM-89-66
℄ NEW LEVEE
MATCH LINE STA.144+00
STA.145+00
STA.150+00
1V ON 3H
EXIST. CONC. OUTLET
NEW CONC. OUTLET INV.EL.25.24
℄ VALLEY DRIVE
REMOVE 24" C.M.P.
WALNUT CREEK
CONSTRUCTION BASELINE
PLAN
℄ NEW GATEWELL M STA.146+94.1.24.2'L
℄ VALLEY DRIVE STA.147+71.3
EL.42.2
EL.39.2
EL.38.2
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
WEST DES MOINES CITY DATUM
60
50
40
30
20
10
144+00
145+00
146+00
147+00
148+00
149+00
150+00
151+00
152+00
153+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE

(A)



PLAN

OFFSET TABLE			
STATION	℄ OFFSET		REMARKS
	LEFT	RIGHT	
139+99.8	0	0	P.I. OF 100'R CURVE
145+05.8	19.6'		
147+87.2	41.7'		
150+19.4	26.9'		PERPENDICULAR TO BACK TANGENT
159+62.7	20'		PERPENDICULAR TO BACK TANGENT



PROFILE

REFERENCES:

1. FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1.
2. FOR TYPICAL SECTIONS, SEE PLATE 23.
3. FOR LOGS OF BORINGS, SEE PLATE 31 & 32
4. FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51.

SCALE: 1" = 50'

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:

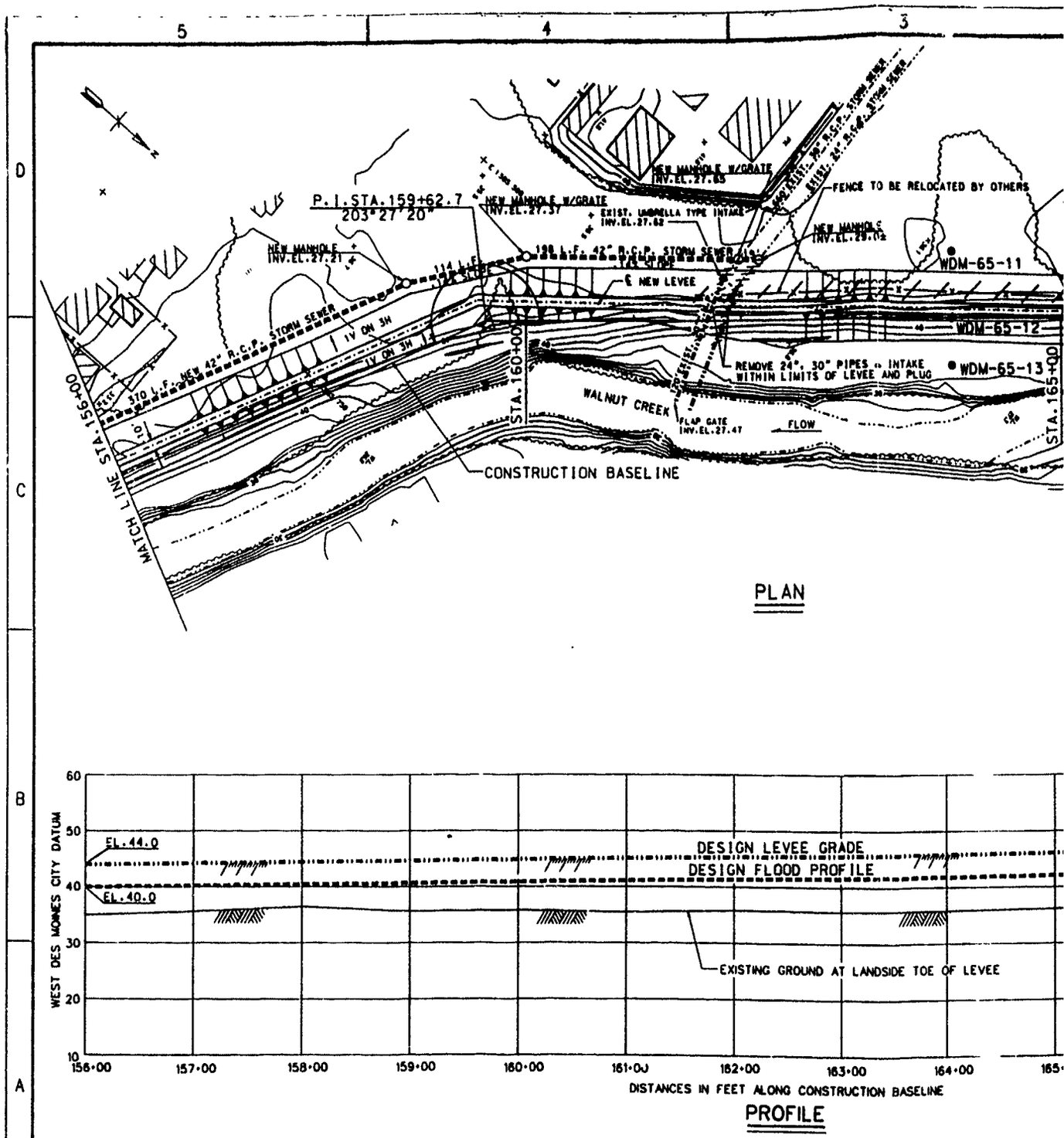
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PLAN AND PROFILE
STA.144+00 TO STA.156+00

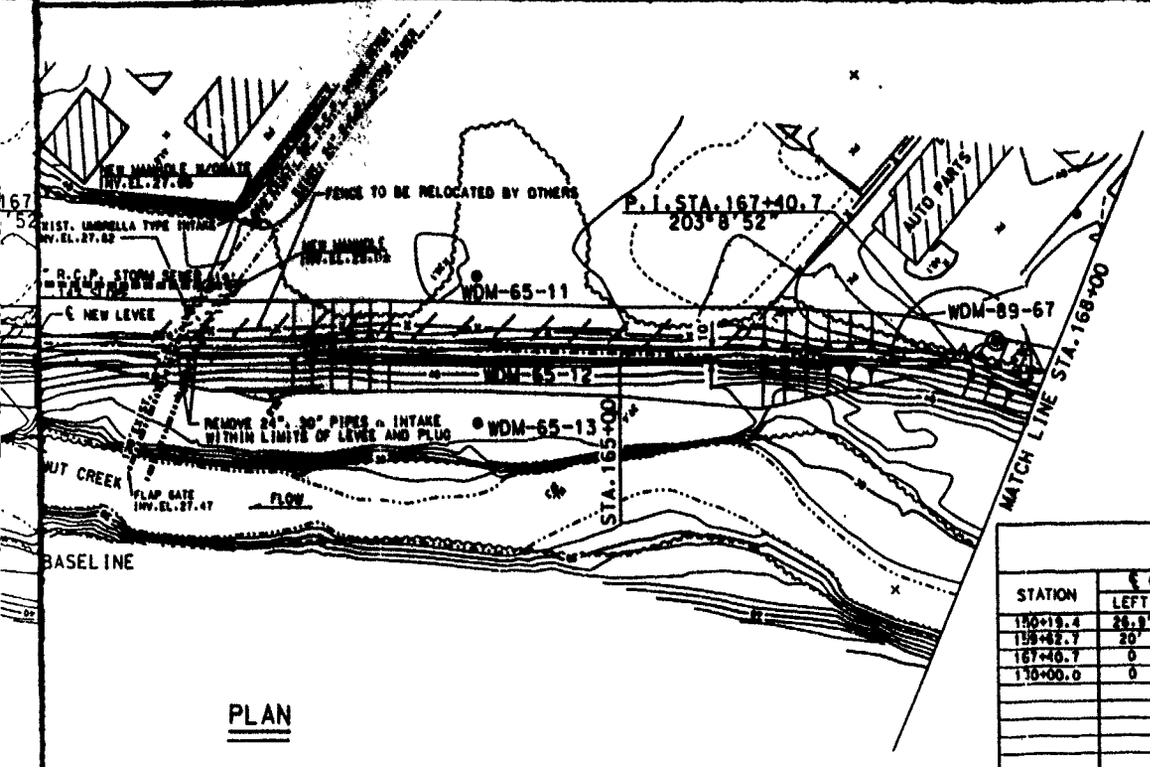
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Date:
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Sheet reference number:
Illustration Number:
Sheet of

PLATE 16

(B)


5
4
3
D
C
B
A
P.I. STA. 159+62.7
203°27'20"
NEW MANHOLE W/GRATE
INV. EL. 27.65
NEW MANHOLE W/GRATE
INV. EL. 27.57
EXIST. UMBRELLA TYPE INTAKE
INV. EL. 27.62
NEW MANHOLE
INV. EL. 27.21
NEW MANHOLE
INV. EL. 29.12
198 L.F. 42" R.C.P. STORM SEWER
114 L.F.
370 L.F. NEW 42" R.C.P. STORM SEWER
1V ON 3H
1V ON 3H
FENCE TO BE RELOCATED BY OTHERS
WDM-65-11
WDM-65-12
WDM-65-13
℄ NEW LEVEE
REMOVE 24", 30" PIPES & INTAKE WITHIN LIMITS OF LEVEE AND PLUG
WALNUT CREEK
FLAP GATE
INV. EL. 27.47
FLOW
MATCH LINE STA. 156+00
STA. 160+00
STA. 165+00
CONSTRUCTION BASELINE
PLAN
60
50
40
30
20
10
WEST DES MOINES CITY DATUM
EL. 44.0
EL. 40.0
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
156+00
157+00
158+00
159+00
160+00
161+00
162+00
163+00
164+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE

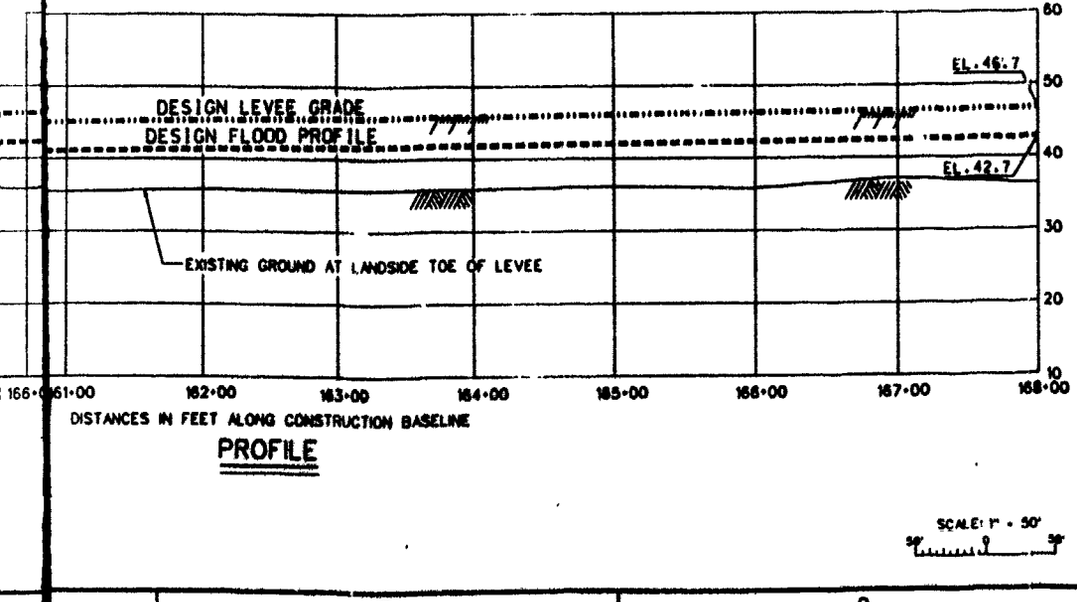
(A)



PLAN

OFFSET TABLE

STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
170+19.4	26.9'		PERPENDICULAR TO BACK TANGENT
175+82.7	20'		PERPENDICULAR TO BACK TANGENT
167+40.7	0	0	
170+00.0	0	0	



PROFILE

SCALE: 1" = 50'

REFERENCES:

1. FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1.
2. FOR TYPICAL SECTIONS, SEE PLATE 23.
3. FOR LOGS OF BORINGS, SEE PLATE 32.
4. FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51

Revisions Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by
Drawn by
Checked by
Reviewed by
Approved by

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

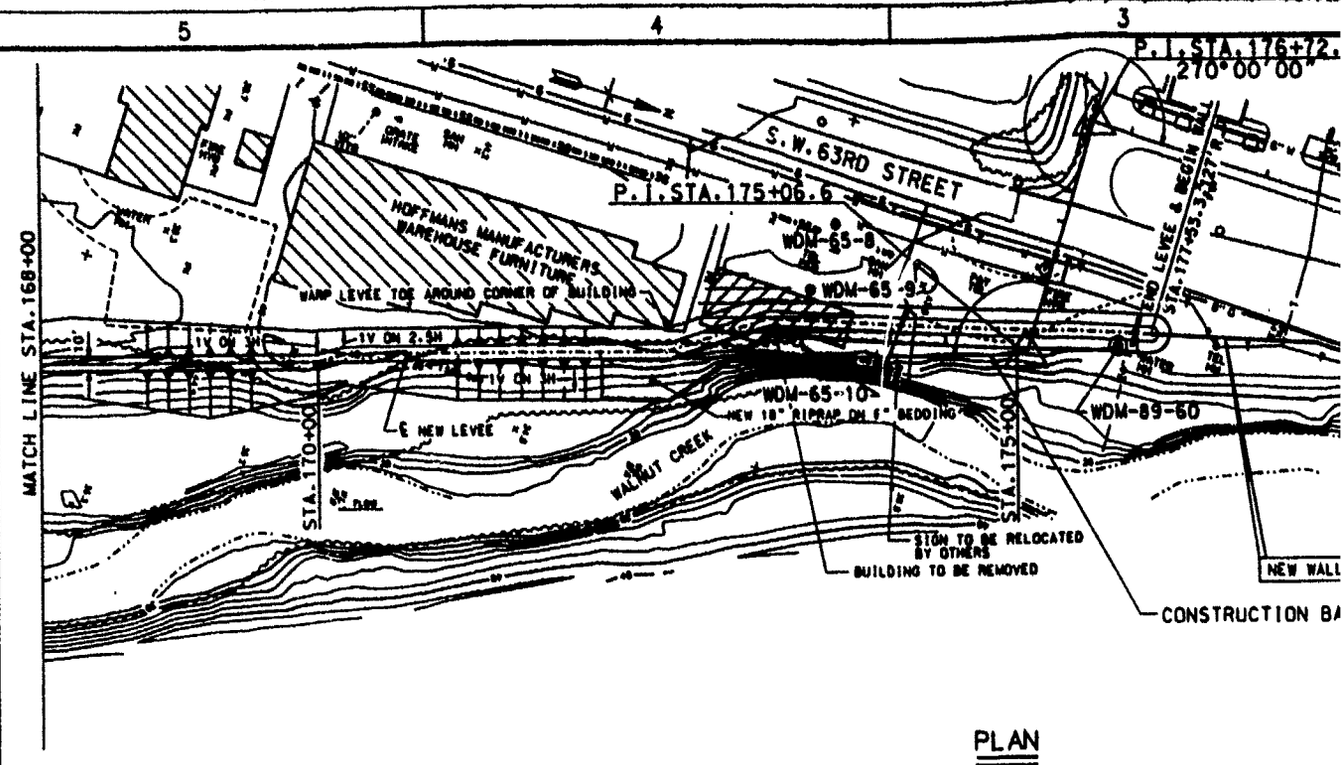
PLAN AND PROFILE
STA. 158+00 to STA. 168+00

Scales: AS SHOWN
Date
Drawing Number

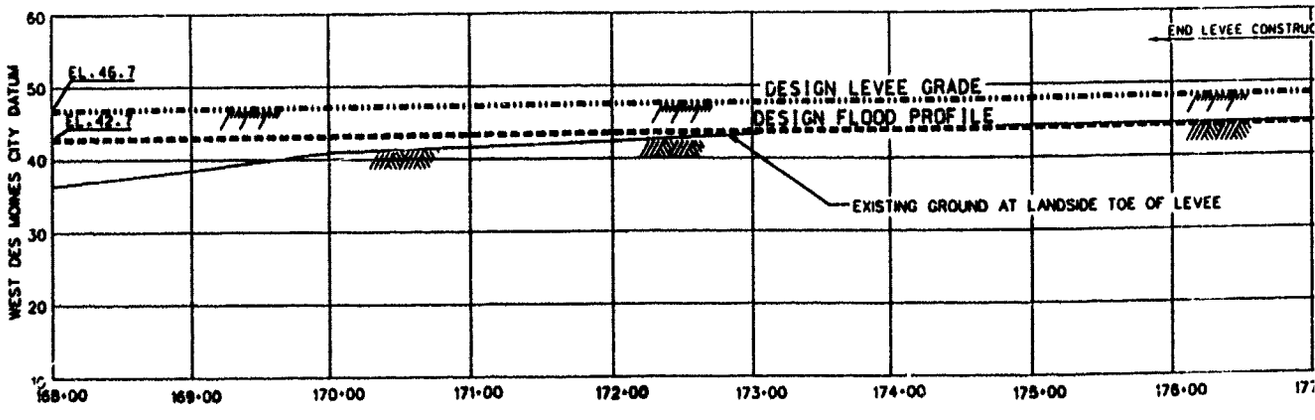
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PLATE 17

(B)

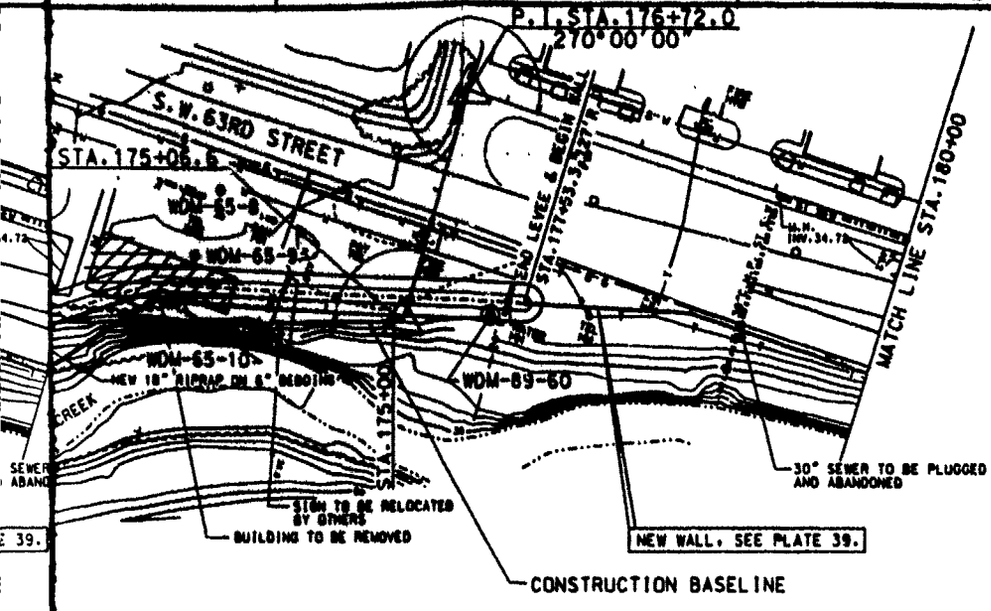


PLAN



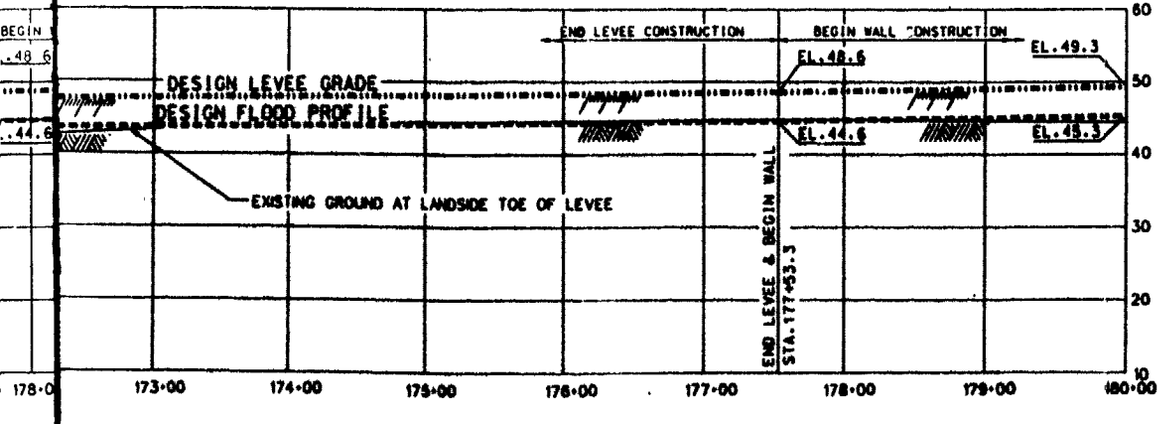
PROFILE

(A)



PLAN

OFFSET TABLE			
STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
167+40.7	0	0	
170+00.0	0	0	
170+30.7	5.3'		
172+47.5	4.8'		
173+89.3	27.1'		
176+46.9		97.1'	
178+42.0		107.6'	



PROFILE

REFERENCES:
1. FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2. FOR TYPICAL SECTIONS, SEE PLATE 23
3. FOR LOGS OF BORINGS, SEE PLATE 32.
4. FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 31.

Revisions Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by
Drawn by
Checked by
Reviewed by
Approved by

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

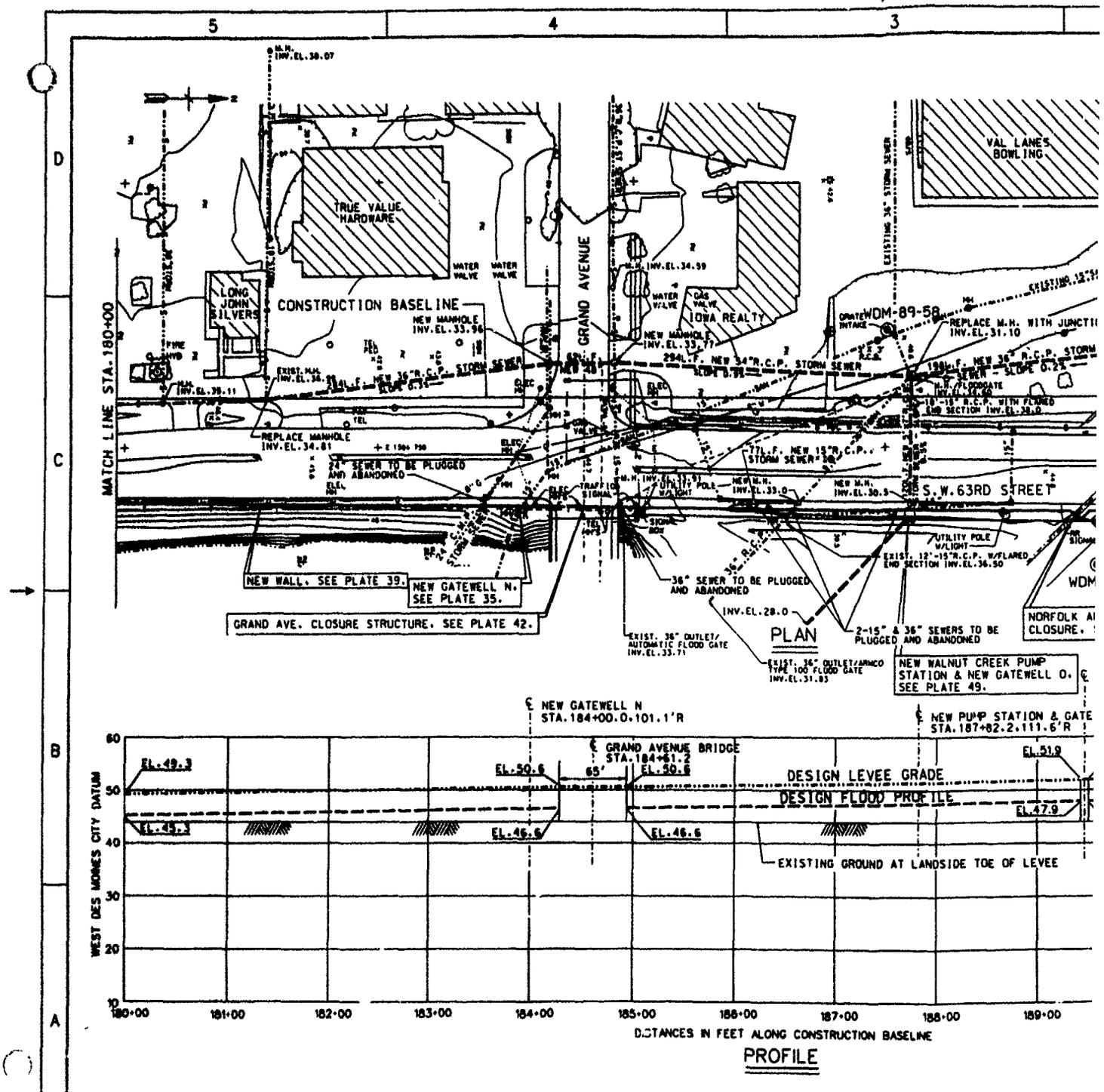
PLAN AND PROFILE
STA. 168+00 to STA. 180+00

Scale: AS SHOWN
Date
Drawing number
Sheet reference numbers
Sheet of

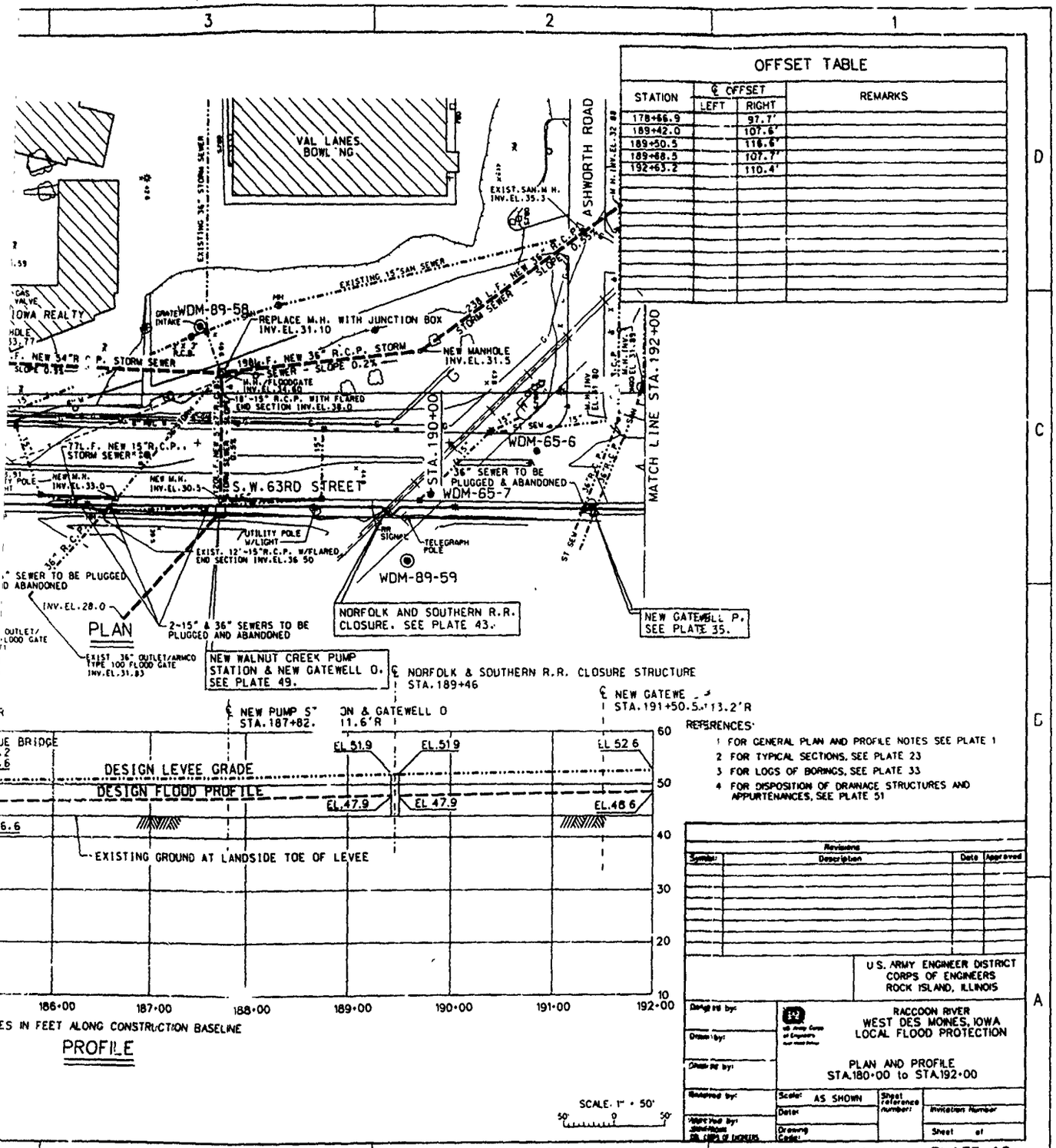
SCALE: 1" = 50'

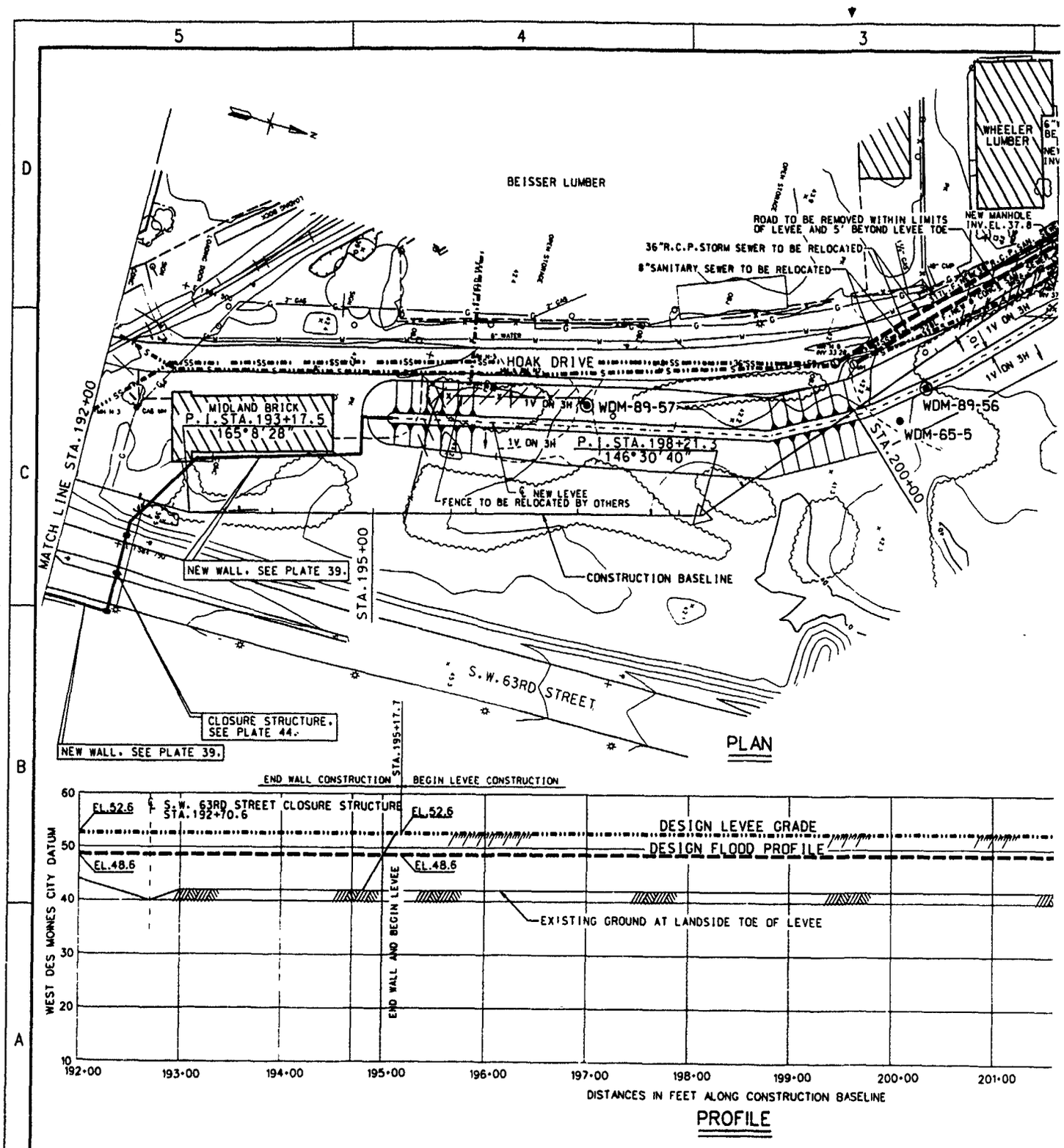
PLATE 18

(B)

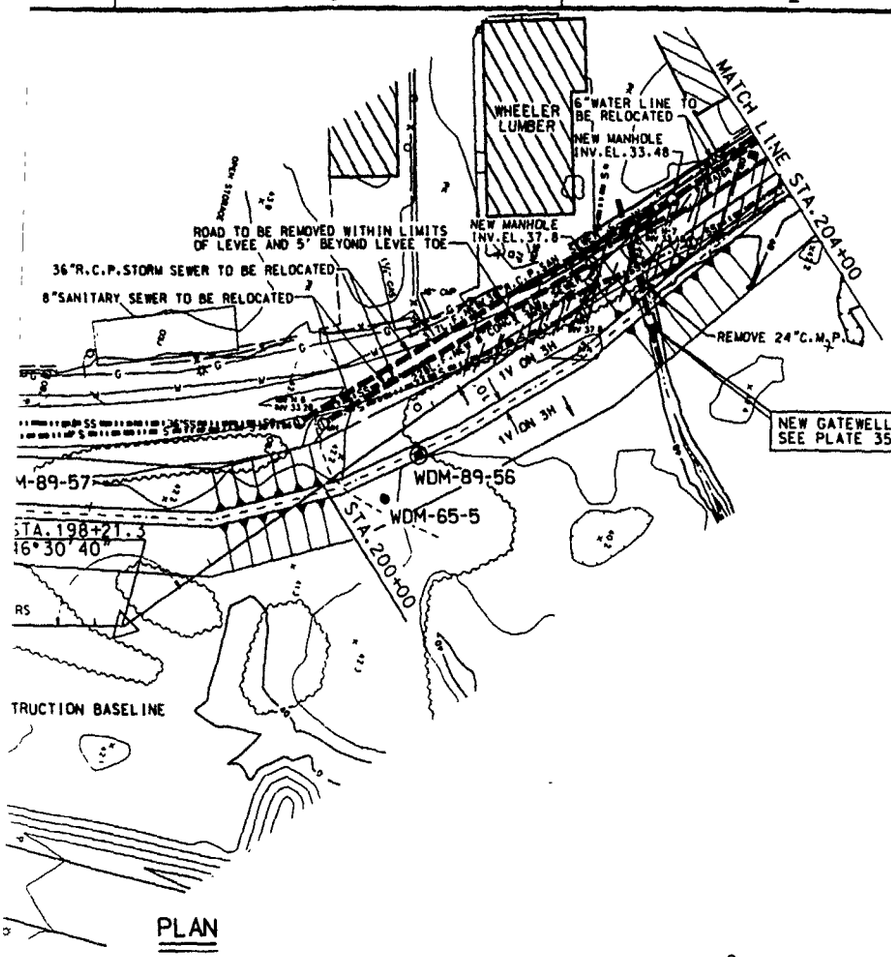

5
4
3
D
C
B
A
MATCH LINE STA. 180+00
TRUE VALUE HARDWARE
LONG JOHN SILVERS
CONSTRUCTION BASELINE
GRAND AVENUE
IOWA REALTY
VAL LANES BOWLING
EXISTING 36" STORM SEWER
WDM-89-58
REPLACE M.H. WITH JUNCTION
INV.EL. 31.10
NEW MANHOLE INV.EL. 33.96
NEW MANHOLE INV.EL. 33.77
294 L.F. NEW 54"R.C.P. STORM SEWER
180 L.F. NEW 36" R.C.P. STORM SEWER - SLOPE 0.2%
M.H. INV.EL. 34.59
M.H. INV.EL. 39.11
EXIST. M.H. INV.EL. 38.39
REPLACE MANHOLE INV.EL. 34.81
24" SEWER TO BE PLUGGED AND ABANDONED
77 L.F. NEW 15"R.C.P. STORM SEWER
M.H. INV.EL. 31.91
NEW M.H. INV.EL. 33.0
NEW M.H. INV.EL. 30.5
S.W. 63RD STREET
TRAFFIC SIGNAL
UTILITY POLE W/LIGHT
SIGNAL BOX
EXIST. 12"-15"R.C.P. W/FLARED END SECTION INV.EL. 36.50
NEW WALL, SEE PLATE 39.
NEW GATEWELL N. SEE PLATE 35.
GRAND AVE. CLOSURE STRUCTURE, SEE PLATE 42.
36" SEWER TO BE PLUGGED AND ABANDONED
INV.EL. 28.0
EXIST. 36" OUTLET/ AUTOMATIC FLOOD GATE INV.EL. 33.71
2-15" & 36" SEWERS TO BE PLUGGED AND ABANDONED
EXIST. 36" OUTLET/ARMCO TYPE 100 FLOOD GATE INV.EL. 31.83
NEW WALNUT CREEK PUMP STATION & NEW GATEWELL O. SEE PLATE 49.
PLAN
℄ NEW GATEWELL N STA. 184+00.0, 101.1'R
℄ GRAND AVENUE BRIDGE STA. 184+61.2
℄ NEW PUMP STATION & GATE STA. 187+82.2, 111.6'R
EL. 49.3
EL. 50.6
65'
EL. 50.6
EL. 51.9
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EL. 47.9
EL. 49.3
EL. 46.6
EL. 46.6
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
WEST DES MOINES CITY DATUM
60
50
40
30
20
10
180+00
181+00
182+00
183+00
184+00
185+00
186+00
187+00
188+00
189+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE

(A)


OFFSET TABLE
STATION
℄ OFFSET
LEFT
RIGHT
REMARKS
178+86.9 97.7'
189+42.0 107.6'
189+50.5 116.6'
189+68.5 107.7'
192+63.2 110.4'
VAL LANES BOWLING
ASHWORTH ROAD
EXISTING 36" STORM SEWER
EXISTING 15" SAN SEWER
EXIST. SAN M.H. INV.EL.35.3
IOWA REALTY
WDM-89-58
REPLACE M.H. WITH JUNCTION BOX INV.EL.31.10
238 L.F. NEW 36" R.C.P. STORM SEWER
198 L.F. NEW 36" R.C.P. STORM SEWER - SLOPE 0.2%
NEW MANHOLE INV.EL.31.5
M.H. FLOODGATE INV.EL.34.60
18"-15" R.C.P. WITH FLARED END SECTION INV.EL.38.0
77 L.F. NEW 15" R.C.P. STORM SEWER
NEW M.H. INV.EL.33.0
NEW M.H. INV.EL.30.5
S.W.63RD STREET
STA.190+00
WDM-65-6
36" SEWER TO BE PLUGGED & ABANDONED
WDM-65-7
MATCH LINE STA.192+00
UTILITY POLE W/LIGHT
EXIST. 12"-15" R.C.P. W/FLARED END SECTION INV.EL.36.50
TELEGRAPH POLE
WDM-89-59
SEWER TO BE PLUGGED & ABANDONED INV.EL.28.0
PLAN
2-15" & 36" SEWERS TO BE PLUGGED AND ABANDONED
NORFOLK AND SOUTHERN R.R. CLOSURE. SEE PLATE 43.
NEW GATEWELL P. SEE PLATE 35.
EXIST. 36" OUTLET/ARMCO TYPE 100 FLOOD GATE INV.EL.31.83
NEW WALNUT CREEK PUMP STATION & NEW GATEWELL O. SEE PLATE 49.
℄ NORFOLK & SOUTHERN R.R. CLOSURE STRUCTURE STA.189+46
℄ NEW PUMP S" ON & GATEWELL O STA.187+82. 11.6'R
℄ NEW GATEWE _ STA.191+50.5 13.2'R
EL.51.9
EL.51.9
EL.52.6
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EL.47.9
EL.47.9
EL.48.6
46.6
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
60
50
40
30
20
10
186+00
187+00
188+00
189+00
190+00
191+00
192+00
ICES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE
SCALE: 1" = 50'
50' 0 50'
REFERENCES:
1 FOR GENERAL PLAN AND PROFILE NOTES SEE PLATE 1
2 FOR TYPICAL SECTIONS, SEE PLATE 23
3 FOR LOGS OF BORINGS, SEE PLATE 33
4 FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51
Revisions
Symbol
Description
Date
Approved
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ROCK ISLAND, ILLINOIS
Designed by:
Drawn by:
Checked by:
Recommended by:
Approved by: Joint Chiefs DIV. CORPS OF ENGINEERS
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION
PLAN AND PROFILE
STA.180+00 to STA.192+00
Scale: AS SHOWN
Date:
Drawing Code:
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Invitation Number
Sheet of
3
2
1
PLATE 19
(B)

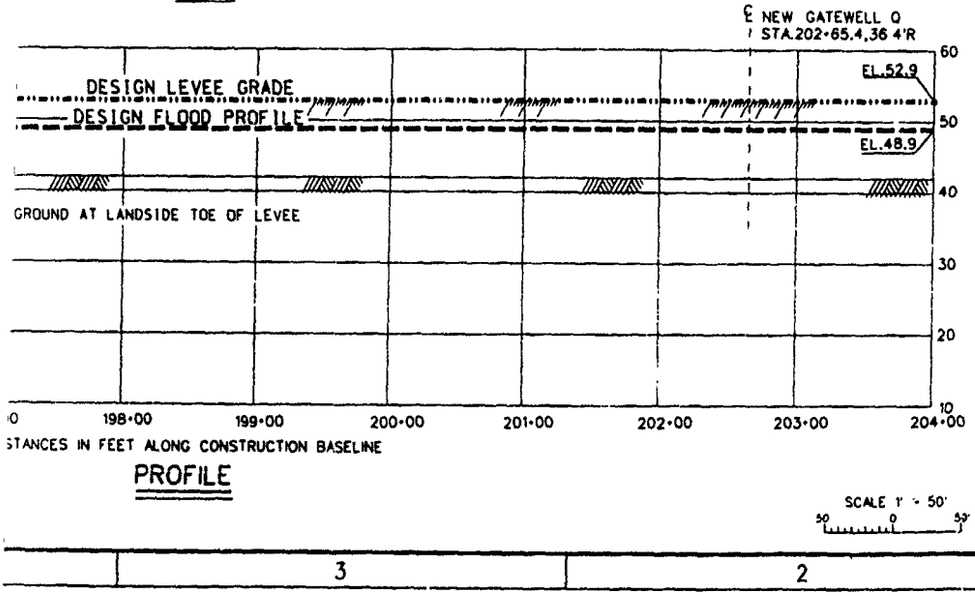

BEISSER LUMBER
WHEELER LUMBER
ROAD TO BE REMOVED WITHIN LIMITS OF LEVEE AND 5' BEYOND LEVEE TOE
NEW MANHOLE INV. EL. 37.8
36"R.C.P. STORM SEWER TO BE RELOCATED
8"SANITARY SEWER TO BE RELOCATED
HOAK DRIVE
MIDLAND BRICK
P.I. STA. 193+17.5
165°8'28"
1V ON 3H
WDM-89-57
WDM-89-56
WDM-65-5
P.I. STA. 198+21.3
146°30'40"
STA. 200+00
MATCH LINE STA. 192+00
℄ NEW LEVEE
FENCE TO BE RELOCATED BY OTHERS
STA. 195+00
NEW WALL. SEE PLATE 39.
CONSTRUCTION BASELINE
S.W. 63RD STREET
CLOSURE STRUCTURE. SEE PLATE 44.
NEW WALL. SEE PLATE 39.
PLAN
END WALL CONSTRUCTION
STA. 195+17.7
BEGIN LEVEE CONSTRUCTION
℄ S.W. 63RD STREET CLOSURE STRUCTURE STA. 192+70.6
EL. 52.6
EL. 48.6
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
END WALL AND BEGIN LEVEE
WEST DES MOINES CITY DATUM
60
50
40
30
20
10
192+00
193+00
194+00
195+00
196+00
197+00
198+00
199+00
200+00
201+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE

(A)



PLAN

OFFSET TABLE			
STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
189+68.5		107.7'	
192+63.2		110.4'	
192+63.2		23.7'	
193+10.7	50.8'		
194+86.3	55.0'		
194+87.6	89.8'		
199+17.9	26.2'		
200+09.3		8.0'	
201+07.8		25.4'	
202+07.4		31.6'	
204+05.0		12.5'	
208+50.9		25.1'	



PROFILE

SCALE 1" = 50'

REFERENCES.

1 FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2 FOR TYPICAL SECTIONS SEE PLATE 23
3 FOR LOGS OF BORINGS, SEE PLATE 33
4 FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by
Checked by
Reviewed by:
Approved by: JOHN R. SIMON CHIEF, CORPS OF ENGINEERS

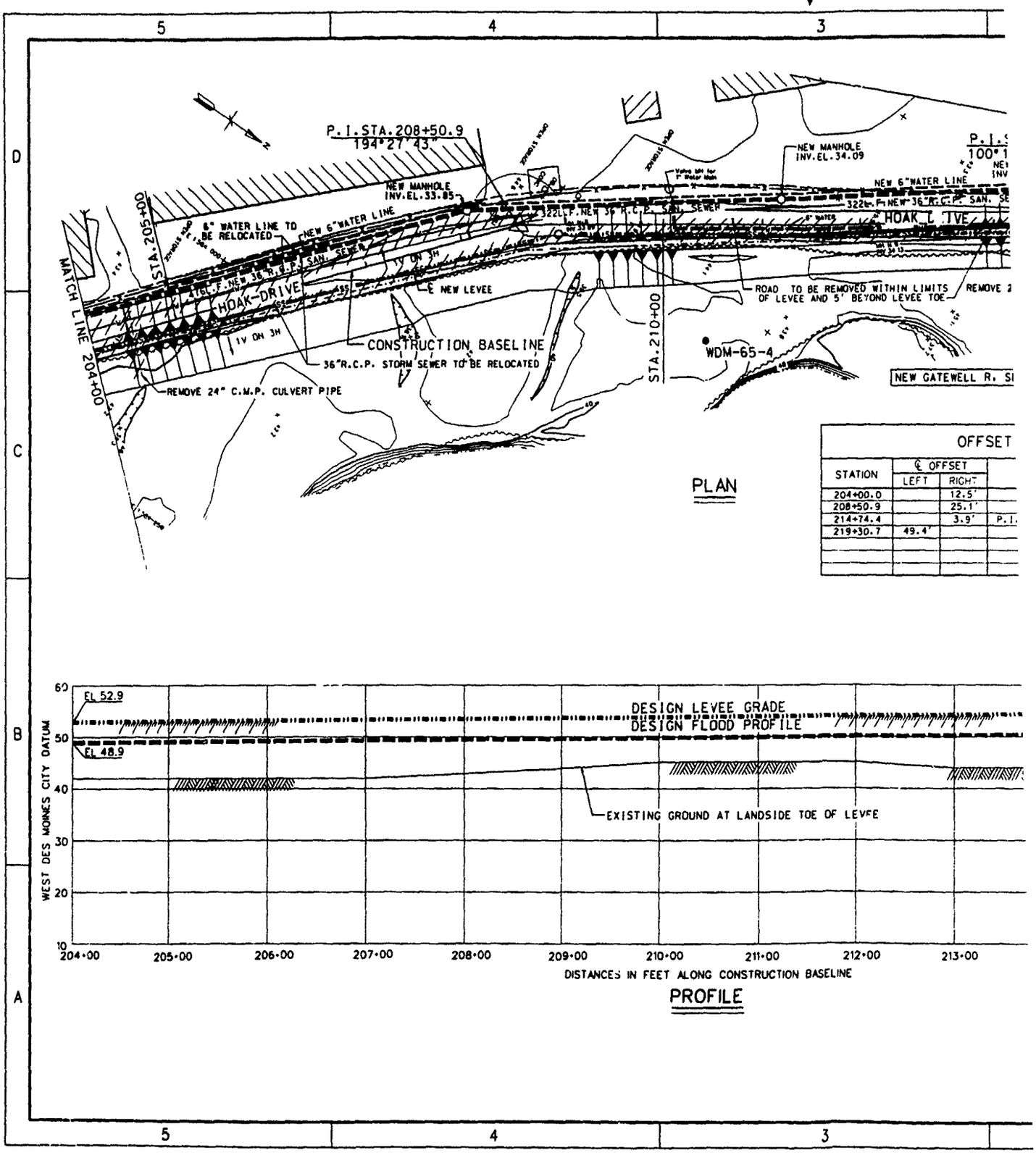
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

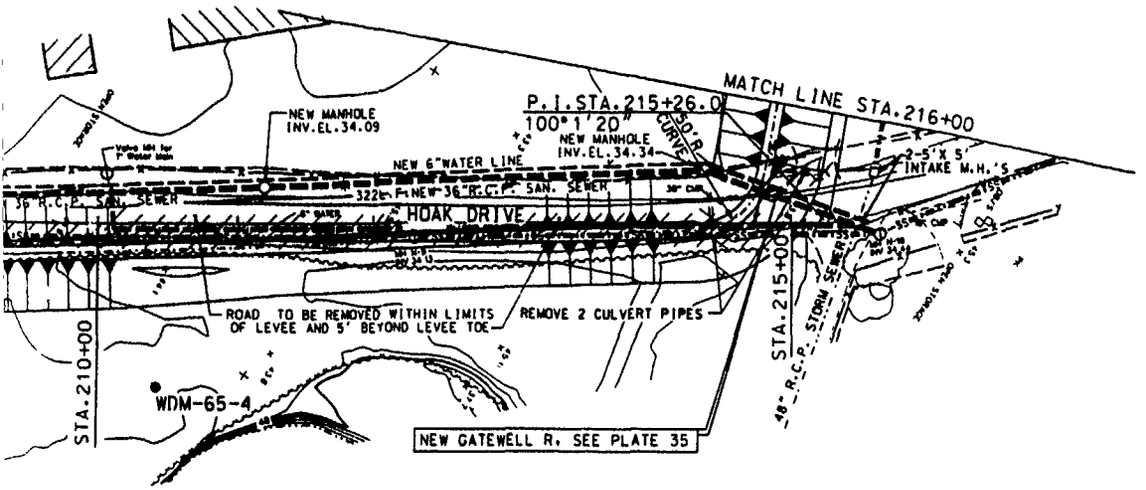
PLAN AND PROFILE
STA.192+00 TO STA.204+00

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PLATE 20

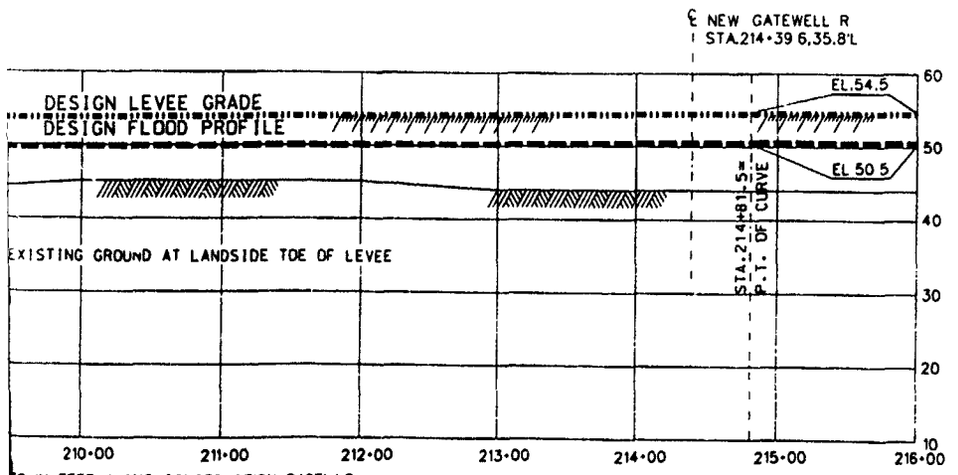
(B)


5
4
3
D
C
B
A
P.I. STA. 208+50.9
194°27'43"
NEW MANHOLE
INV. EL. 33.85
NEW MANHOLE
INV. EL. 34.09
6" WATER LINE TO BE RELOCATED
NEW 6" WATER LINE
322 L.F. NEW 36" R.C.P. SAN. SEWER
HOAK DRIVE
MATCH LINE 204+00
STA. 205+00
STA. 210+00
1V ON 3H
℄ NEW LEVEE
CONSTRUCTION BASELINE
36" R.C.P. STORM SEWER TO BE RELOCATED
REMOVE 24" C.M.P. CULVERT PIPE
ROAD TO BE REMOVED WITHIN LIMITS OF LEVEE AND 5' BEYOND LEVEE TOE
WDM-65-4
NEW GATEWELL R. SI
PLAN
OFFSET
STATION
℄ OFFSET
LEFT
RIGHT
204+00.0
12.5'
208+50.9
25.1'
214+74.4
3.9'
219+30.7
49.4'
EL 52.9
EL 48.9
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
WEST DES MOINES CITY DATUM
60
50
40
30
20
10
204+00
205+00
206+00
207+00
208+00
209+00
210+00
211+00
212+00
213+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE
(A)



PLAN

OFFSET TABLE			
STATION	℄ OFFSET		REMARKS
	LEFT	RIGHT	
204+00.0		12.5'	
208+50.9		25.1'	
214+74.4		3.9'	P.I. 50'R CURVE
219+30.7	49.4'		



PROFILE

REFERENCES

1 FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2 FOR TYPICAL SECTIONS SEE PLATE 23
3 FOR LOGS OF BORINGS SEE PLATE 33
4 FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51

SCALE 1" = 50'

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by: (for the District Engineer, U.S. Corps of Engineers)

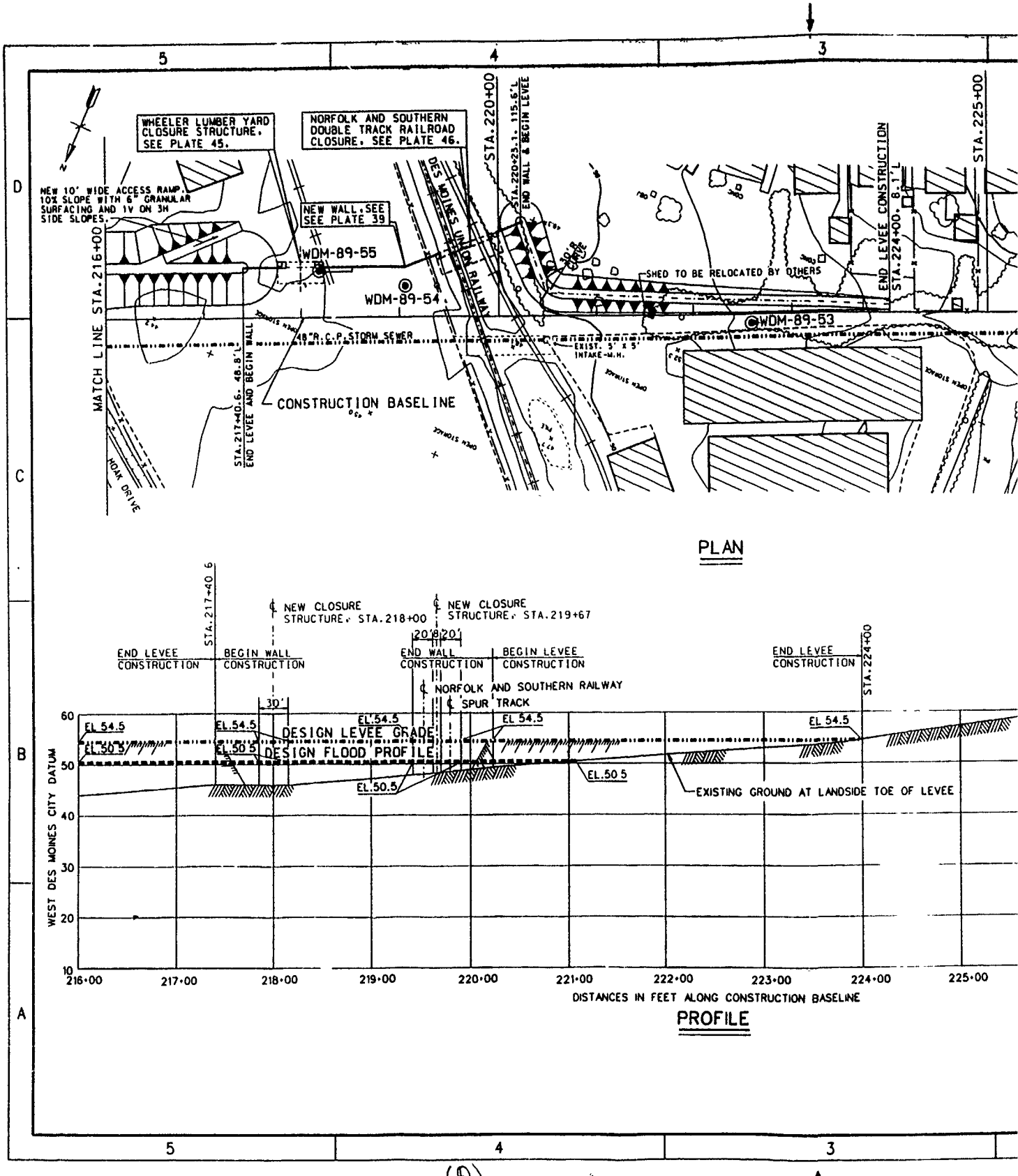
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PLAN AND PROFILE
STA. 204+00 TO STA. 216+00

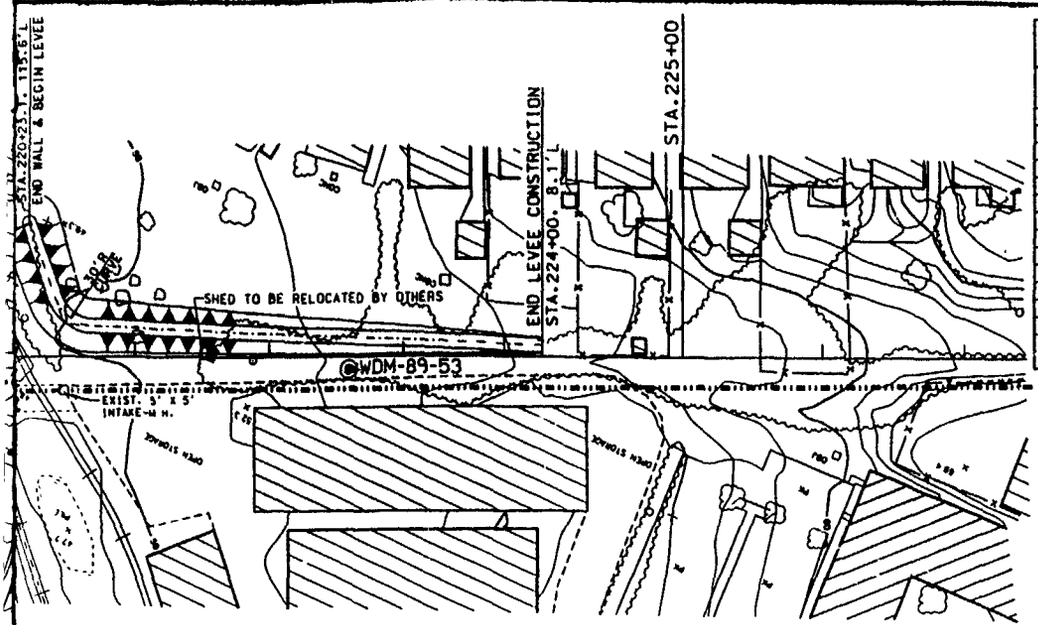
Scale: AS SHOWN
Date:
Drawing Code:
Sheet reference number:
Invitation Number:
Sheet of

PLATE 21

(B)


WHEELER LUMBER YARD CLOSURE STRUCTURE, SEE PLATE 45.
NORFOLK AND SOUTHERN DOUBLE TRACK RAILROAD CLOSURE, SEE PLATE 46.
STA.220+00
STA.220+23.1, 115.6'L END WALL & BEGIN LEVEE
STA.225+00
END LEVEE CONSTRUCTION STA.224+00, 8.1'L
NEW 10' WIDE ACCESS RAMP, 10% SLOPE WITH 6" GRANULAR SURFACING AND 1V ON 3H SIDE SLOPES.
NEW WALL, SEE SEE PLATE 39
WDM-89-55
WDM-89-54
DES MOINES UNION RAILWAY
SHED TO BE RELOCATED BY OTHERS
WDM-89-53
MATCH LINE STA.216+00
48"R.C.P. STORM SEWER
EXIST. 5' X 5' INTAKE-M.H.
STA.217+40.6, 48.8'L END LEVEE AND BEGIN WALL
CONSTRUCTION BASELINE
HOAK DRIVE
PLAN
STA.217+40.6
℄ NEW CLOSURE STRUCTURE, STA.218+00
℄ NEW CLOSURE STRUCTURE, STA.219+67
20'
8'
20'
END LEVEE CONSTRUCTION
BEGIN WALL CONSTRUCTION
END WALL CONSTRUCTION
BEGIN LEVEE CONSTRUCTION
END LEVEE CONSTRUCTION
STA.224+00
℄ NORFOLK AND SOUTHERN RAILWAY
℄ SPUR TRACK
30'
EL 54.5
EL.50.5
DESIGN LEVEE GRADE
DESIGN FLOOD PROFILE
EXISTING GROUND AT LANDSIDE TOE OF LEVEE
WEST DES MOINES CITY DATUM
60
50
40
30
20
10
216+00
217+00
218+00
219+00
220+00
221+00
222+00
223+00
224+00
225+00
DISTANCES IN FEET ALONG CONSTRUCTION BASELINE
PROFILE

(A)



PLAN

OFFSET TABLE			
STATION	℄ OFFSET LEFT	℄ OFFSET RIGHT	REMARKS
214+74.4		3.9'	P.I. 50'R CURVE
219+06.6	56.0'		
220+23.1	115.6'		
220+48.6	22.4'		P.I. 30'R CURVE
224+00.0	8.1'		END LEVEE PROJECT

RE
STA 219+67

GIN LEVEE
NSTRUCTION

END LEVEE
CONSTRUCTION

STA.224+00

SOUTHERN RAILWAY

CK

54.5

EL.54.5

EL 50.5

EXISTING GROUND AT LANDSIDE TOE OF LEVEE

60
50
40
30
20
10

221+00 222+00 223+00 224+00 225+00 226+00 227+00 228+00

DISTANCES IN FEET ALONG CONSTRUCTION BASELINE

PROFILE

SCALE 1" = 50'

50' 0 50'

REFERENCES:

1 FOR GENERAL PLAN AND PROFILE NOTES, SEE PLATE 1
2 FOR TYPICAL SECTIONS SEE PLATE 23
3 FOR LOGS OF BORINGS, SEE PLATE 33
4 FOR DISPOSITION OF DRAINAGE STRUCTURES AND APPURTENANCES, SEE PLATE 51

NOTE:

BORINGS NO. WDM-65-1, 2 & 3 ARE NOT SHOWN THEY ARE LOCATED OUTSIDE OF THE CURRENT PROJECT LIMITS.

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:
CHIEF, ILLINOIS
CIVIL WORKS BRANCH
CHIEF, CORPS OF ENGINEERS

US Army Corps of Engineers

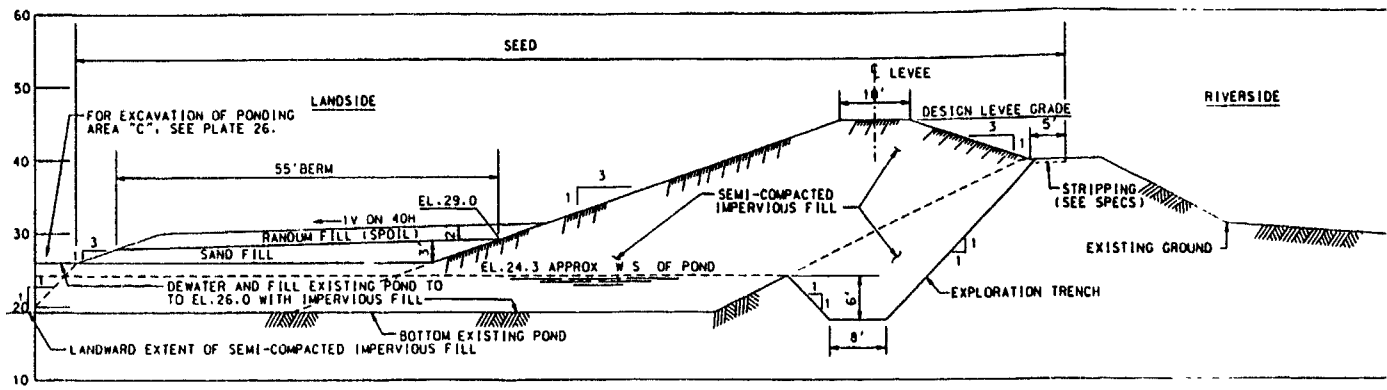
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PLAN AND PROFILE
STA.218+00 TO STA.228+00

Scale: AS SHOWN
Date:
Drawing Code:
Sheet reference number:
Invitation Number:
Sheet of

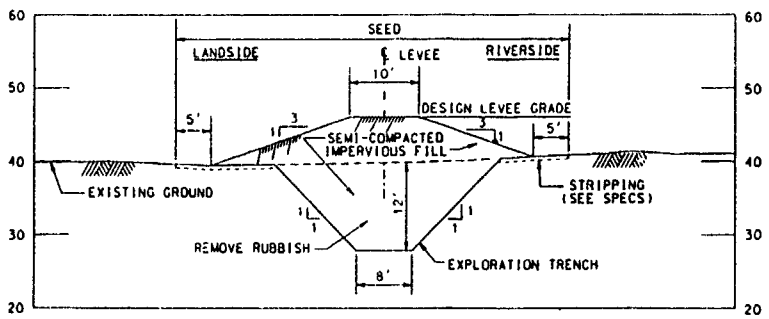
PLATE 22

(B)



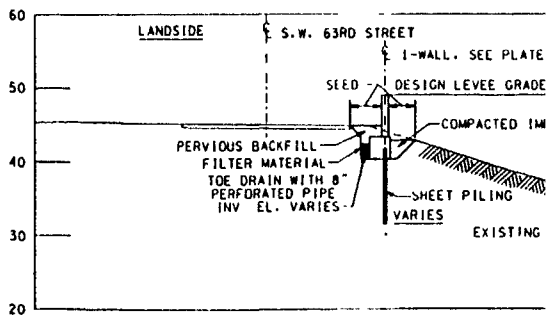
STA.84+00

STA.81+00 TO STA.86+00



STA.65+00

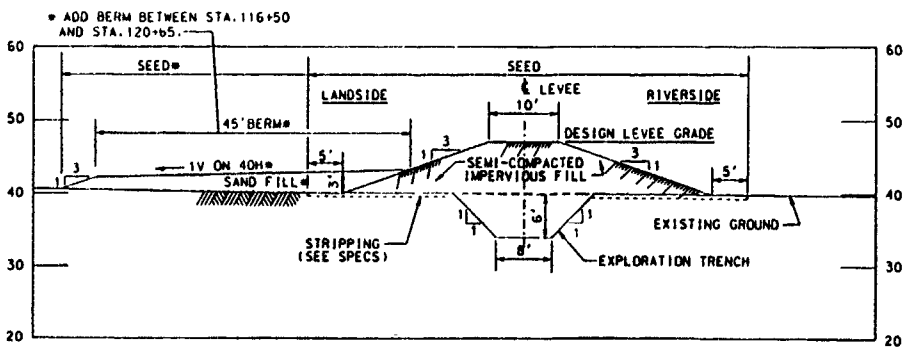
STA.58+00 TO STA.66+50



STA.180+00

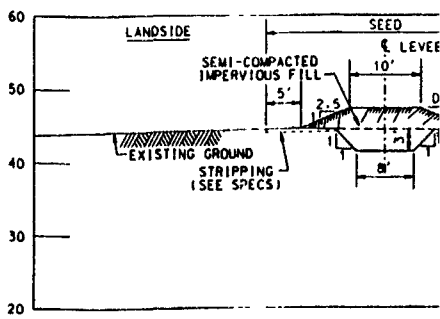
STA.177+53 TO STA.195-

STA.217+40 TO STA.220-



STA.36+00

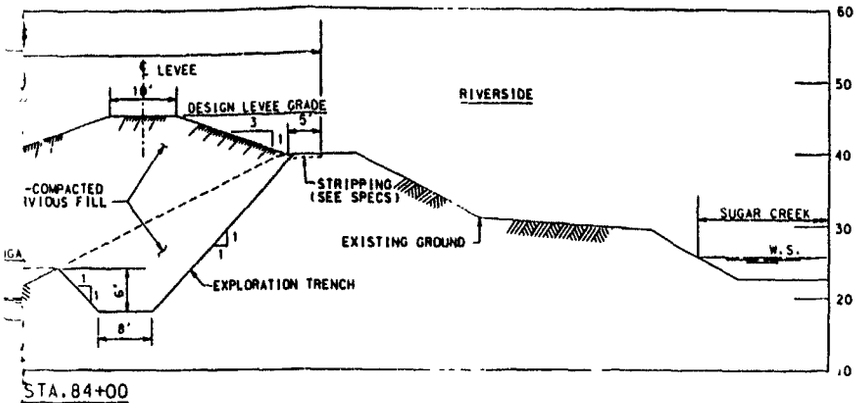
STA.0+00 TO STA.58+00
STA.66+50 TO STA.81+00
STA.86+00 TO STA.170+00
STA.195+17 TO STA.217+40
STA.220+23 TO STA.224+00



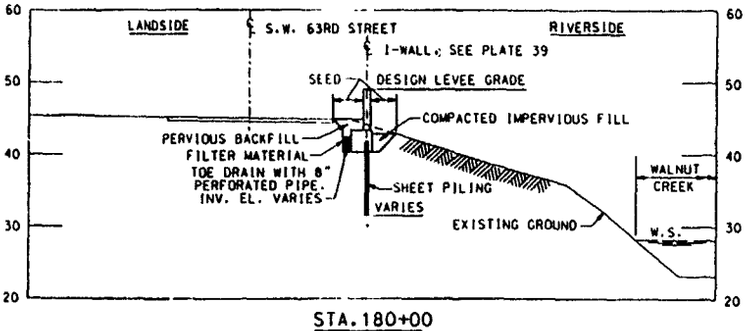
STA.17410

STA.170+00 TO S

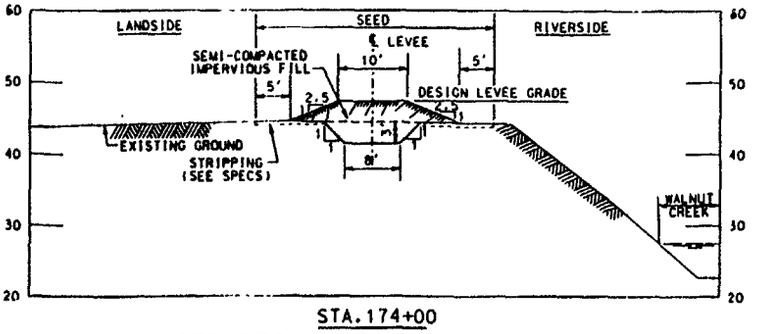
(A)



STA. 84+00
O TO STA. 86+00



STA. 180+00
STA. 177+53 TO STA. 195+17
STA. 217+40 TO STA. 220+23



STA. 174+00
STA. 170+00 TO STA. 177+53

A. 81+00
TA. 217+40

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

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Drawn by:
Checked by:
Revised by:
Approved by:

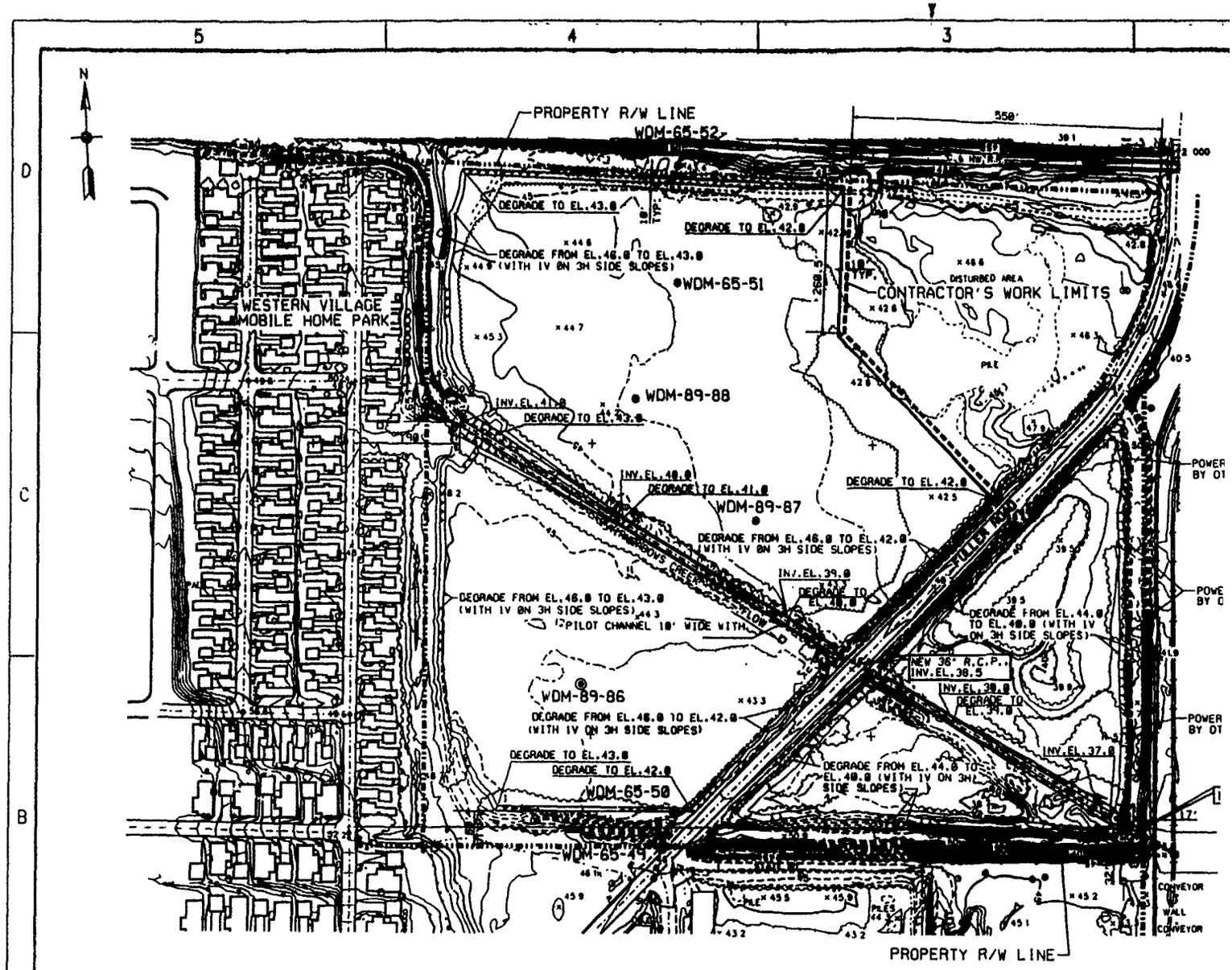
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

TYPICAL LEVEE SECTIONS

Scale: SCALE AS SHOWN
Date:
Drawing Code:
Sheet reference number:
Solicitation Number:
Sheet of

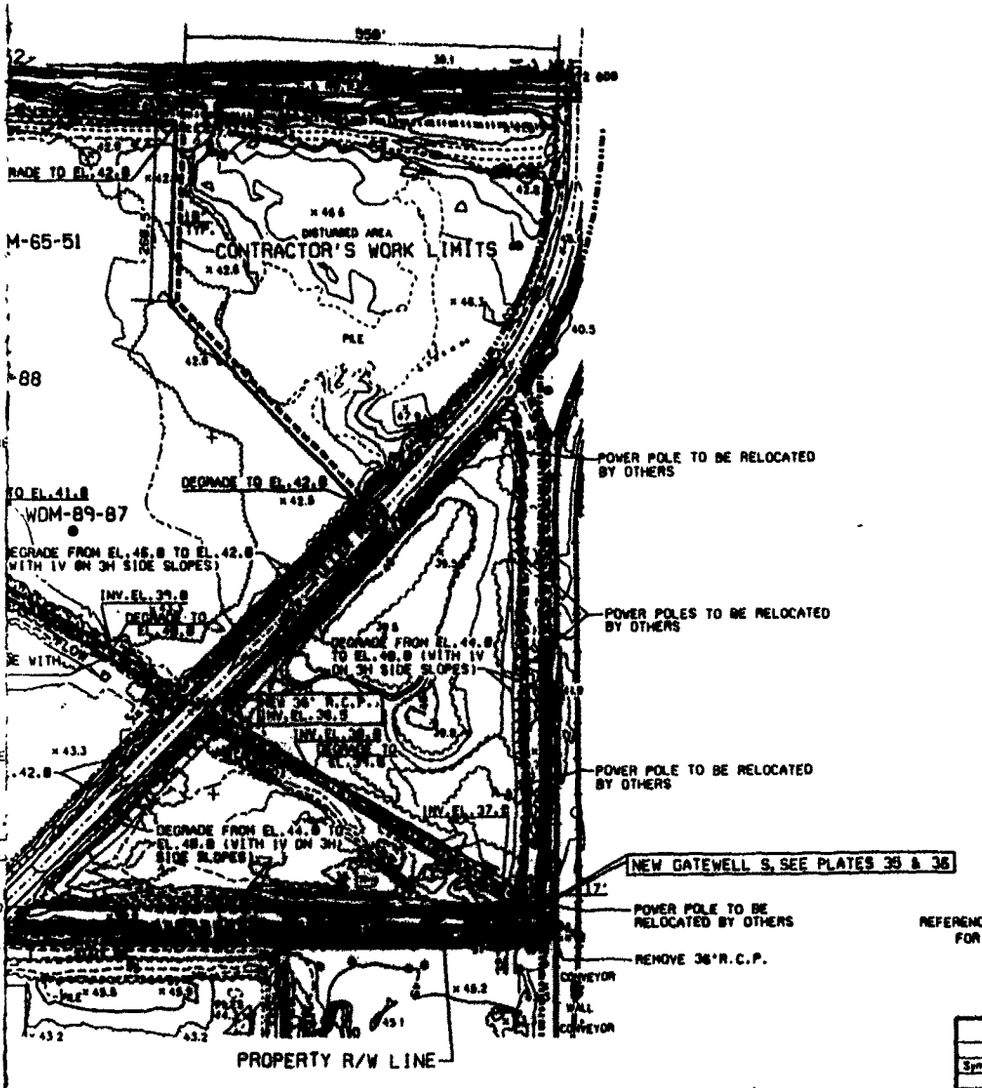
PLATE 23

(B)


5
4
3
D
C
B
A
N
PROPERTY R/W LINE
WDM-65-52
WESTERN VILLAGE MOBILE HOME PARK
WDM-65-51
CONTRACTOR'S WORK LIMITS
DISTURBED AREA
WDM-89-88
WDM-89-87
WDM-89-86
WDM-65-50
WDM-65-49
PILOT CHANNEL 18' WIDE WITH
NEW 36" R.C.P.
INV.EL.38.5
CONVEYOR
WALL CONVEYOR
PROPERTY R/W LINE

PLAN

(A)



REFERENCE:
FOR LOGS OF BORINGS, SEE PLATE 34.

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

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Drawn by:
Checked by:
Reviewed by:
Approved by:

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

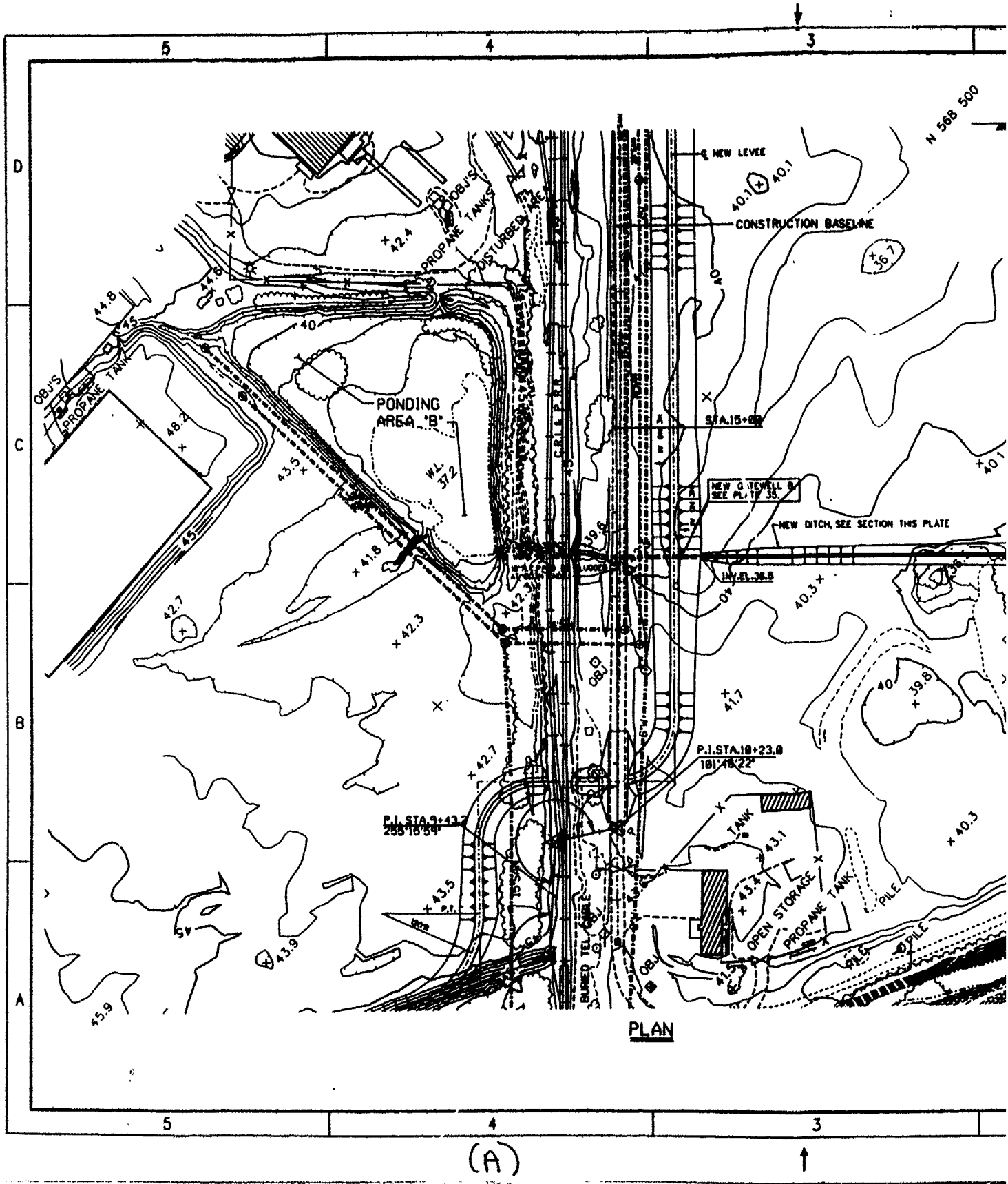
PONDING AND BORROW AREA "A"

Scale: AS SHOWN
Date:
Drawing Code:
Sheet reference number:
Submission Number:
Sheet of

SCALE: 1" = 100'

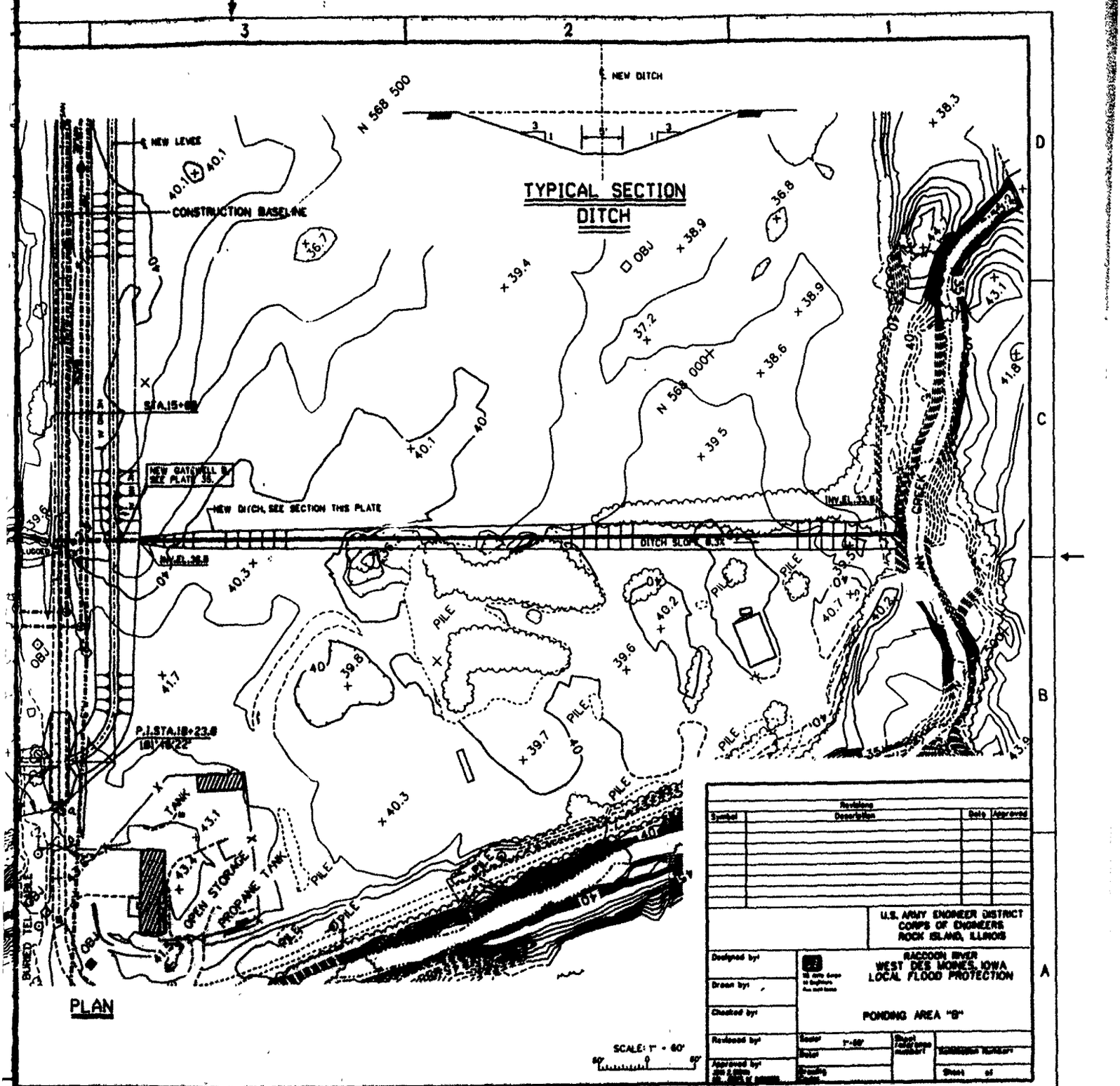
PLATE 24

(B)


5
4
3
D
C
B
A
℄ NEW LEVEE
CONSTRUCTION BASELINE
N 568 500
PROPANE TANK
OBJ'S
DISTURBED AREA
PONDING AREA "B"
W.L. 37.2
C.R.I.& P.R.R.
STA.15+00
NEW GATEWELL B SEE PL. IV 35.
NEW DITCH, SEE SECTION THIS PLATE
INV.EL.38.5
P.I.STA.10+23.0
181°48'22"
P.I.STA.9+43.2
255°15'54"
TANK
OPEN STORAGE
PROPANE TANK
PILE
BURIED TEL. CABLE
42.4
44.8
44.6
45
40
48.2
43.5
41.8
42.7
42.3
39.6
40.3
41.7
39.8
43.1
43.4
43.5
43.9
45.9
41.5
40.1
36.7

PLAN

(A)



Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

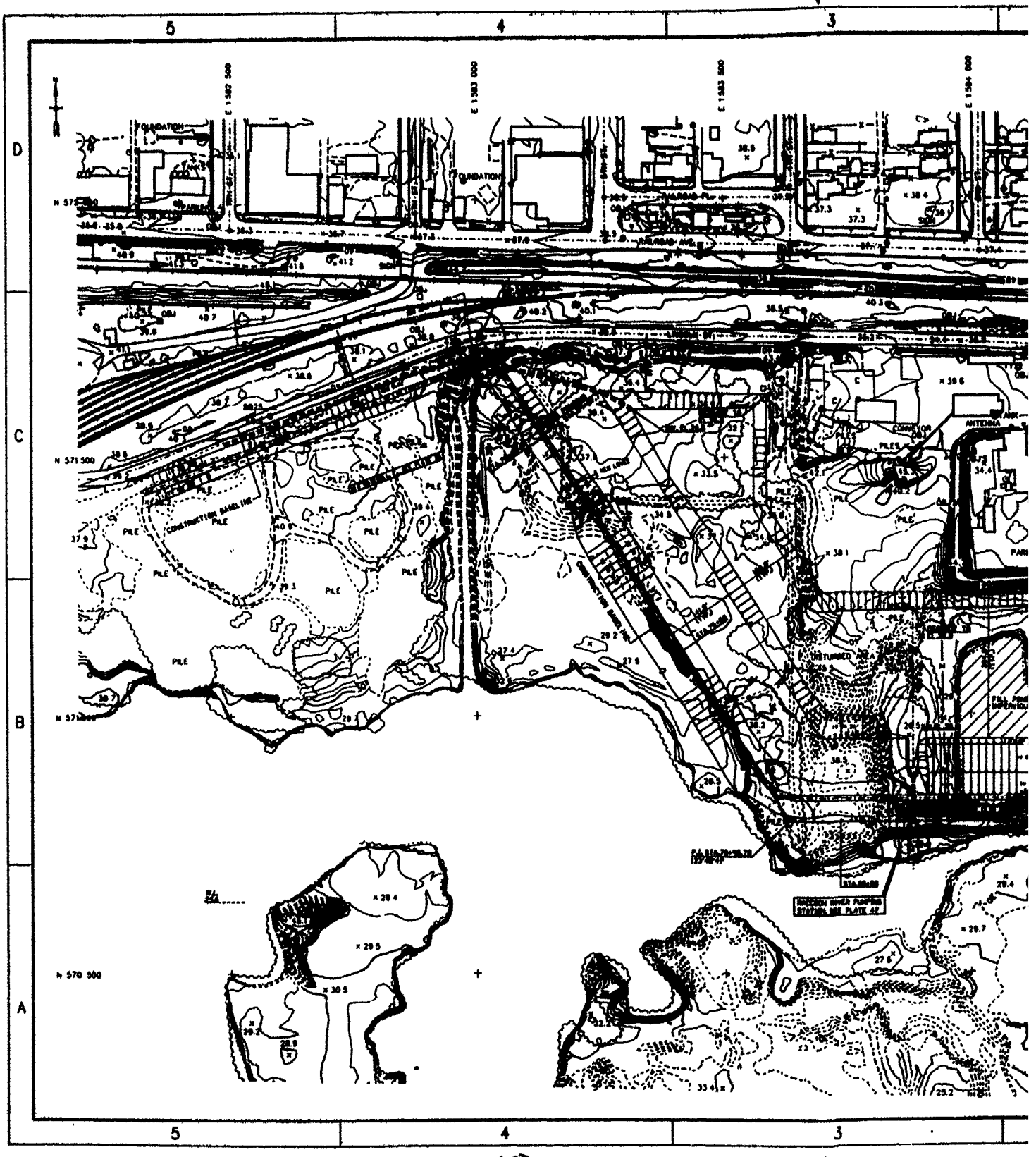
PONDING AREA "B"

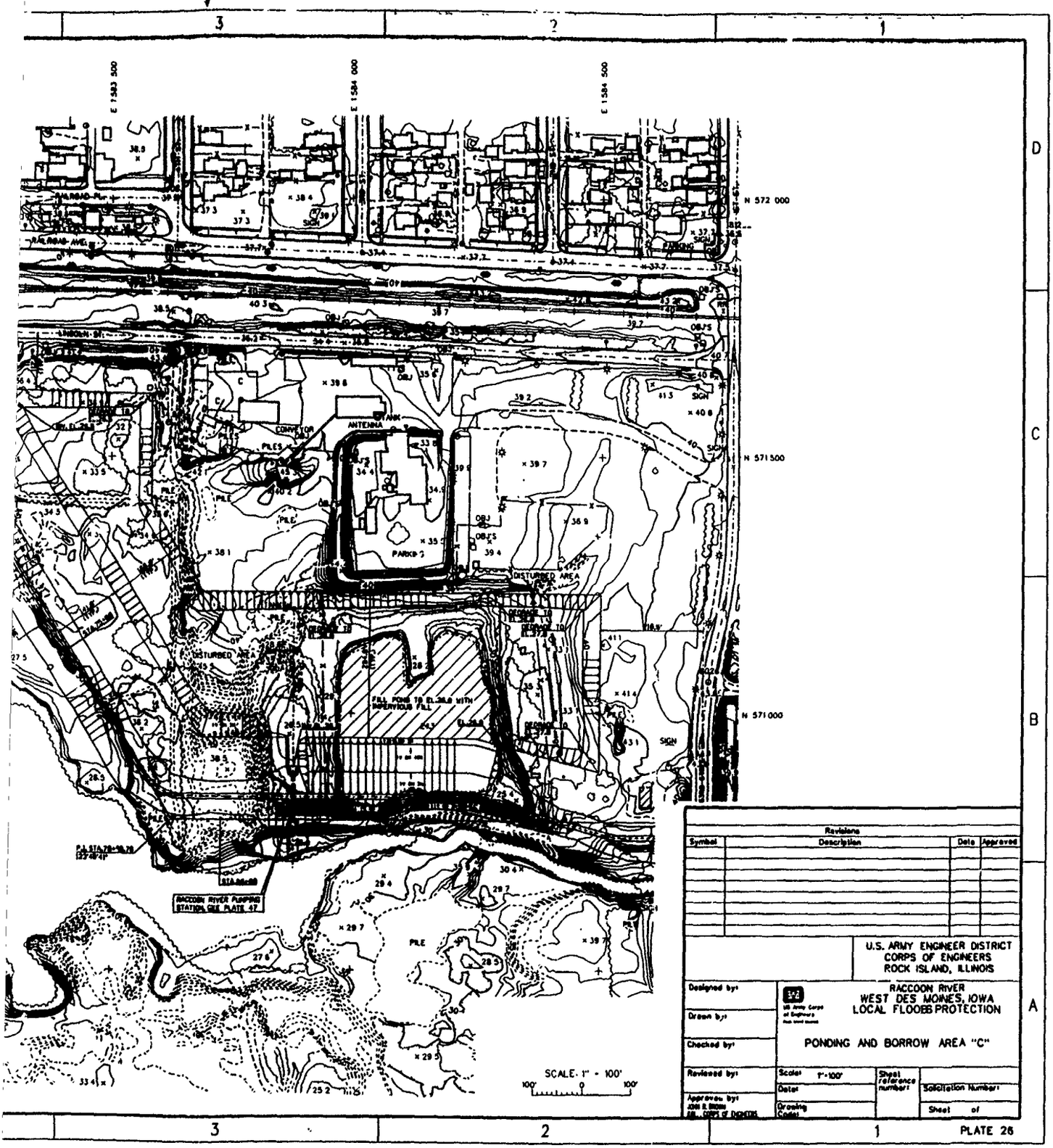
Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:

Scale: 1"=60'
Date:
Drawing No.:
Sheet No.:
Sheet of

PLATE 25

(B)


5
4
3
D
C
B
A
E 1582 500
E 1583 000
E 1583 500
E 1584 000
N 571 500
N 570 500
FOUNDATION
PILE
CONSTRUCTION BASELINE
ANTENNA
PILES
DISTURBED AREA
RAILROAD AVE.
(A)



Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

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Drawn by:
Checked by:
Reviewed by:
Approved by:
JOHN E. BROWN
DIR., CORPS OF ENGINEERS

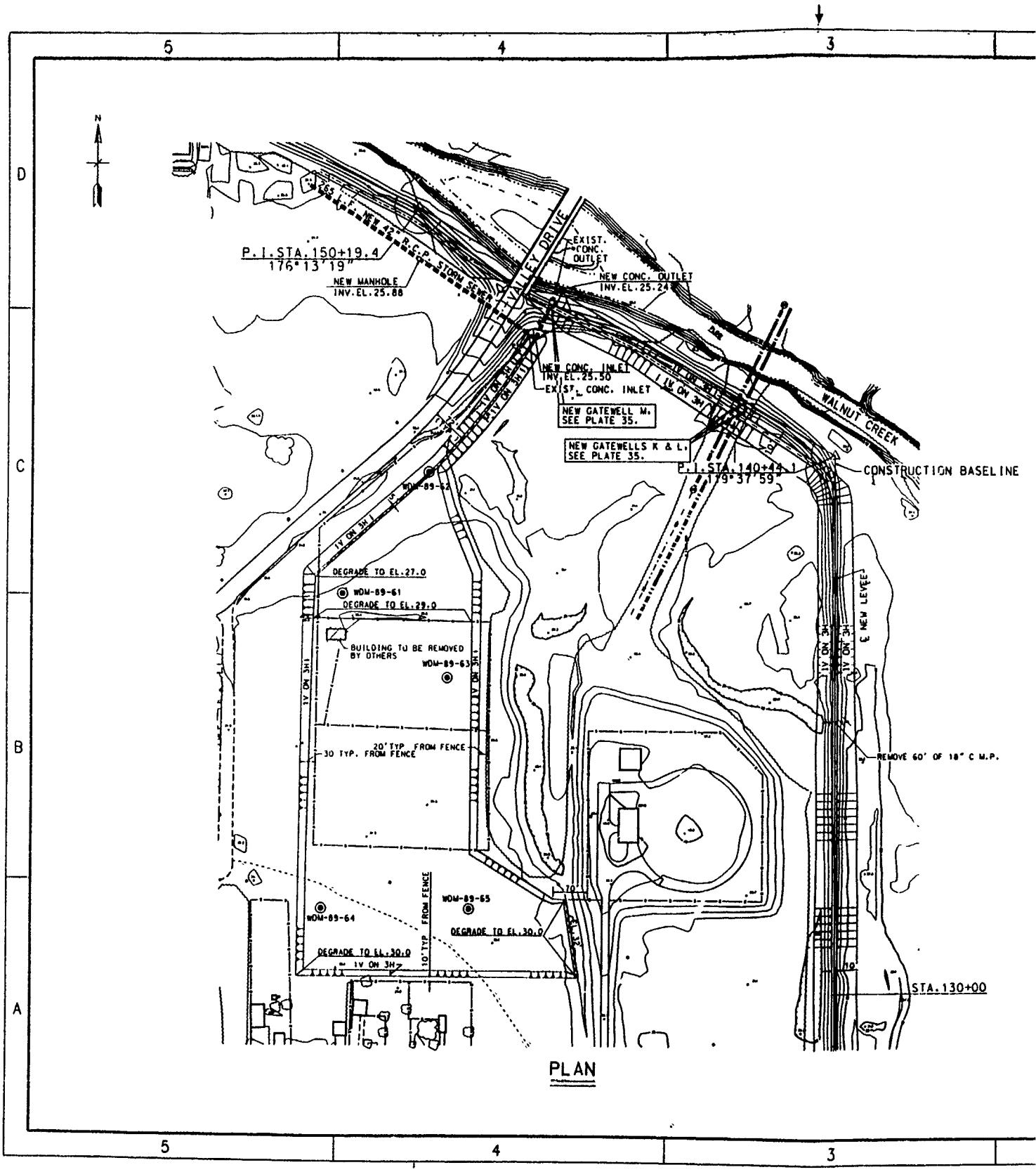
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOBB PROTECTION

PONDING AND BORROW AREA "C"

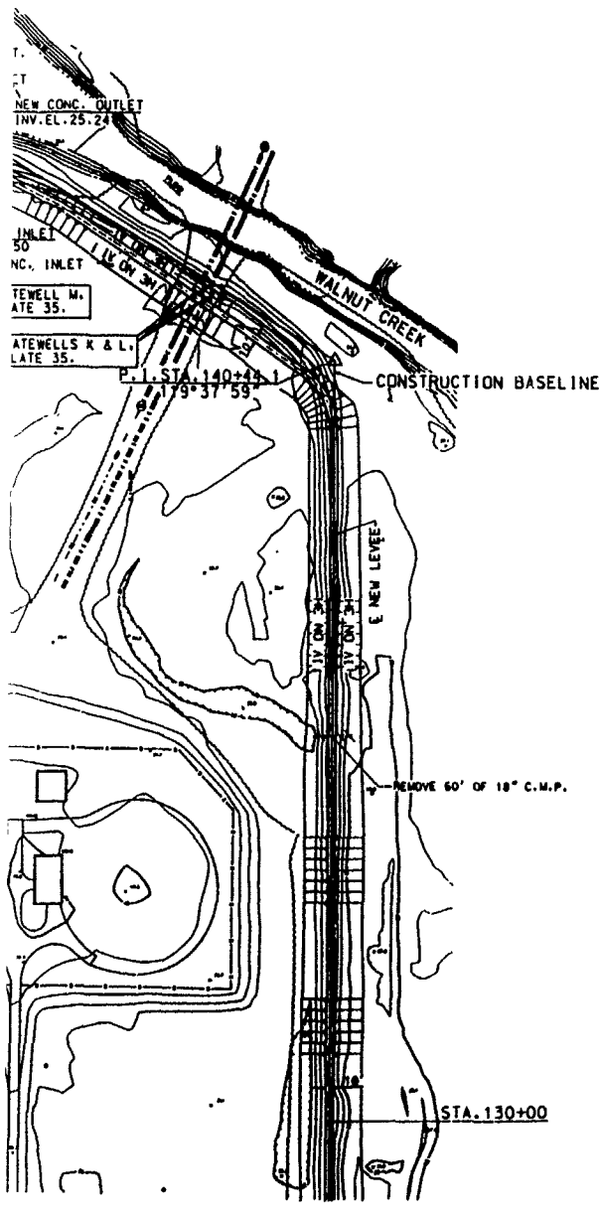
Scale: 1"=100'
Datel:
Drawing Code:
Sheet reference number:
Solicitation Number:
Sheet of

PLATE 26

(B)


5
4
3
D
C
B
A
N
P.I. STA. 150+19.4
176°13'19"
NEW MANHOLE
INV. EL. 25.88
EXIST. CONC. OUTLET
NEW CONC. OUTLET
INV. EL. 25.24
VALLEY DRIVE
NEW CONC. INLET
INV. EL. 25.50
EXIST. CONC. INLET
NEW GATEWELL M.
SEE PLATE 35.
NEW GATEWELLS K & L
SEE PLATE 35.
WALNUT CREEK
P.I. STA. 140+44.1
179°37'59"
CONSTRUCTION BASELINE
WDM-89-62
DEGRADE TO EL. 27.0
WDM-89-61
DEGRADE TO EL. 29.0
BUILDING TO BE REMOVED BY OTHERS
WDM-89-63
20' TYP. FROM FENCE
30 TYP. FROM FENCE
REMOVE 60' OF 18" C.M.P.
WDM-89-64
WDM-89-65
10' TYP. FROM FENCE
DEGRADE TO EL. 30.0
DEGRADE TO EL. 30.0
1V ON 3H
STA. 130+00
PLAN

(A)



REFERENCE:
FOR LOGS OF BORINGS, SEE PLATE 34.

SCALE: 1" = 100'
100' 0 100'

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
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Reviewed by:
Approved by:
JOHN E. BROWN
CHIEF, CORPS OF ENGINEERS

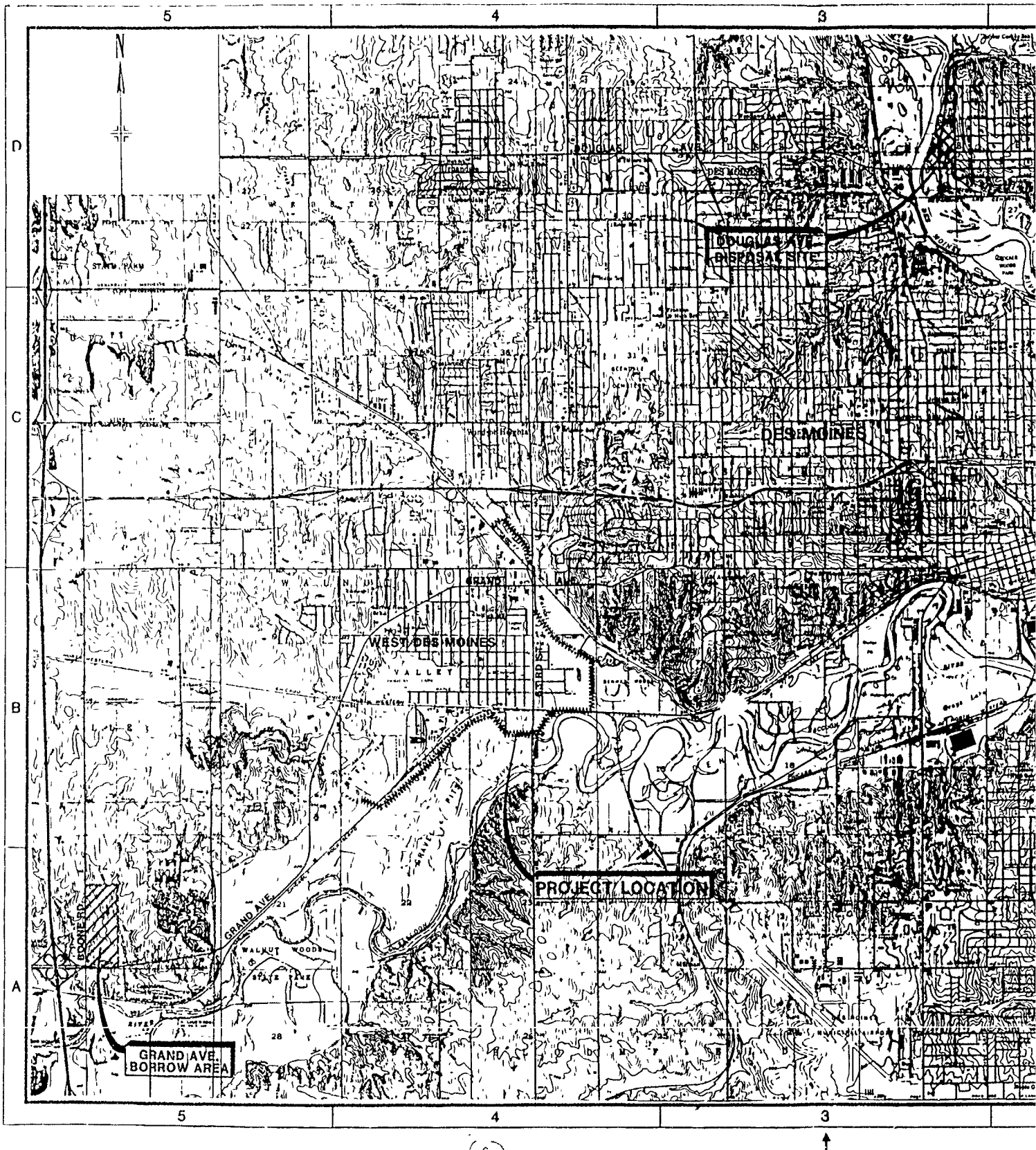
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PONDING AND BORROW AREA "D"

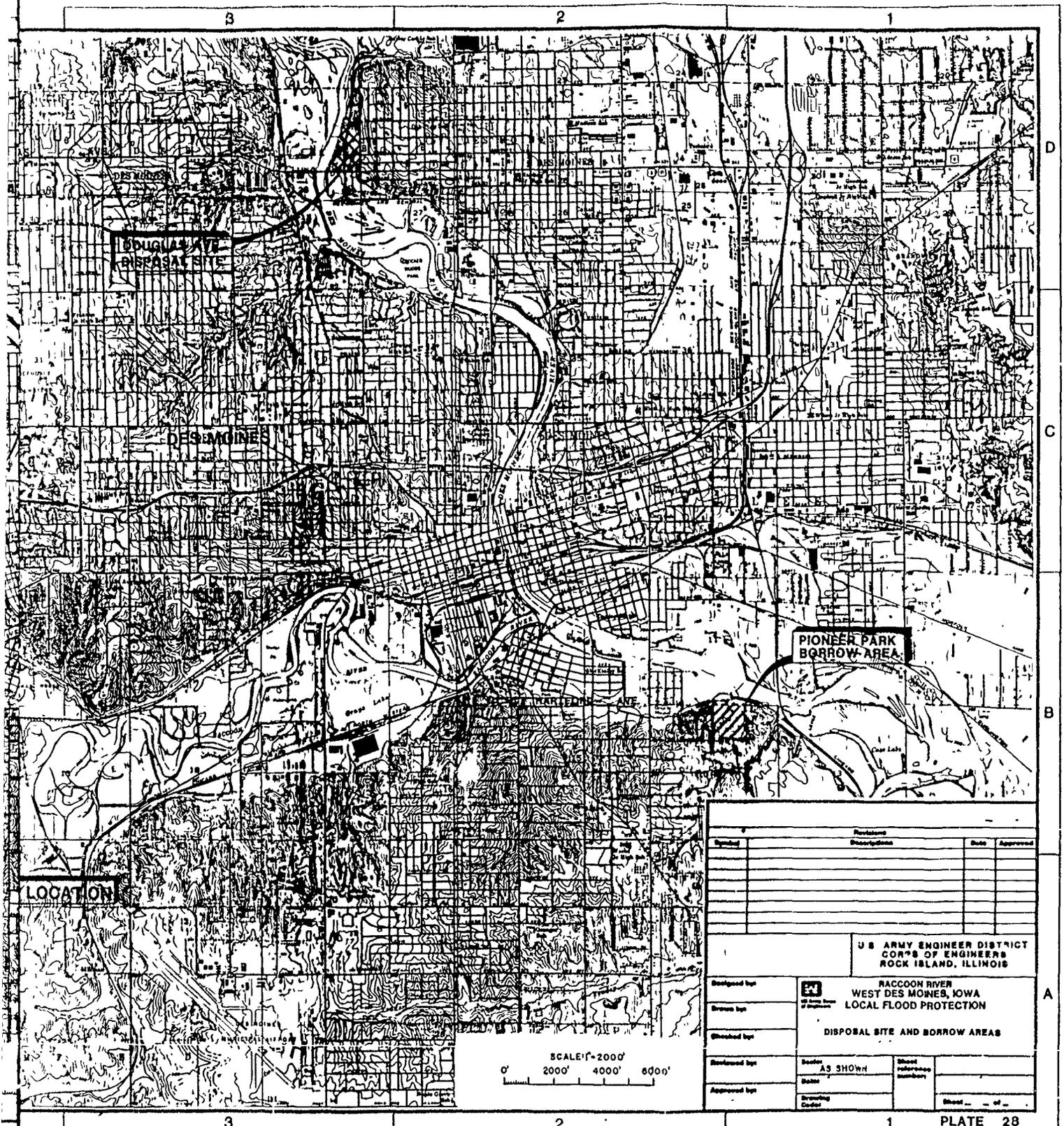
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Date:
Drawing Code:
Sheet reference number:
Invitation Number:
Sheet of

PLATE 27

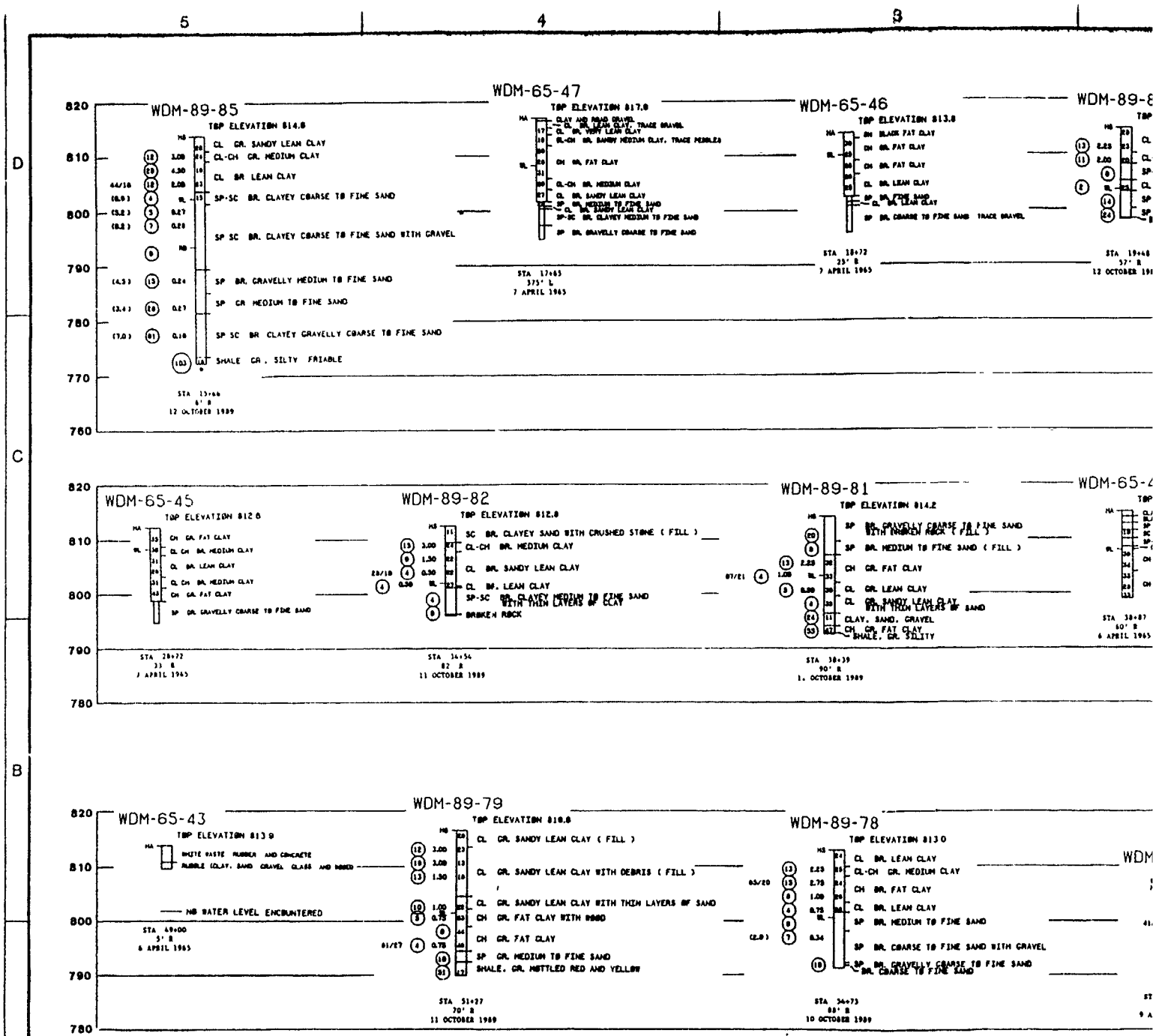
(B)

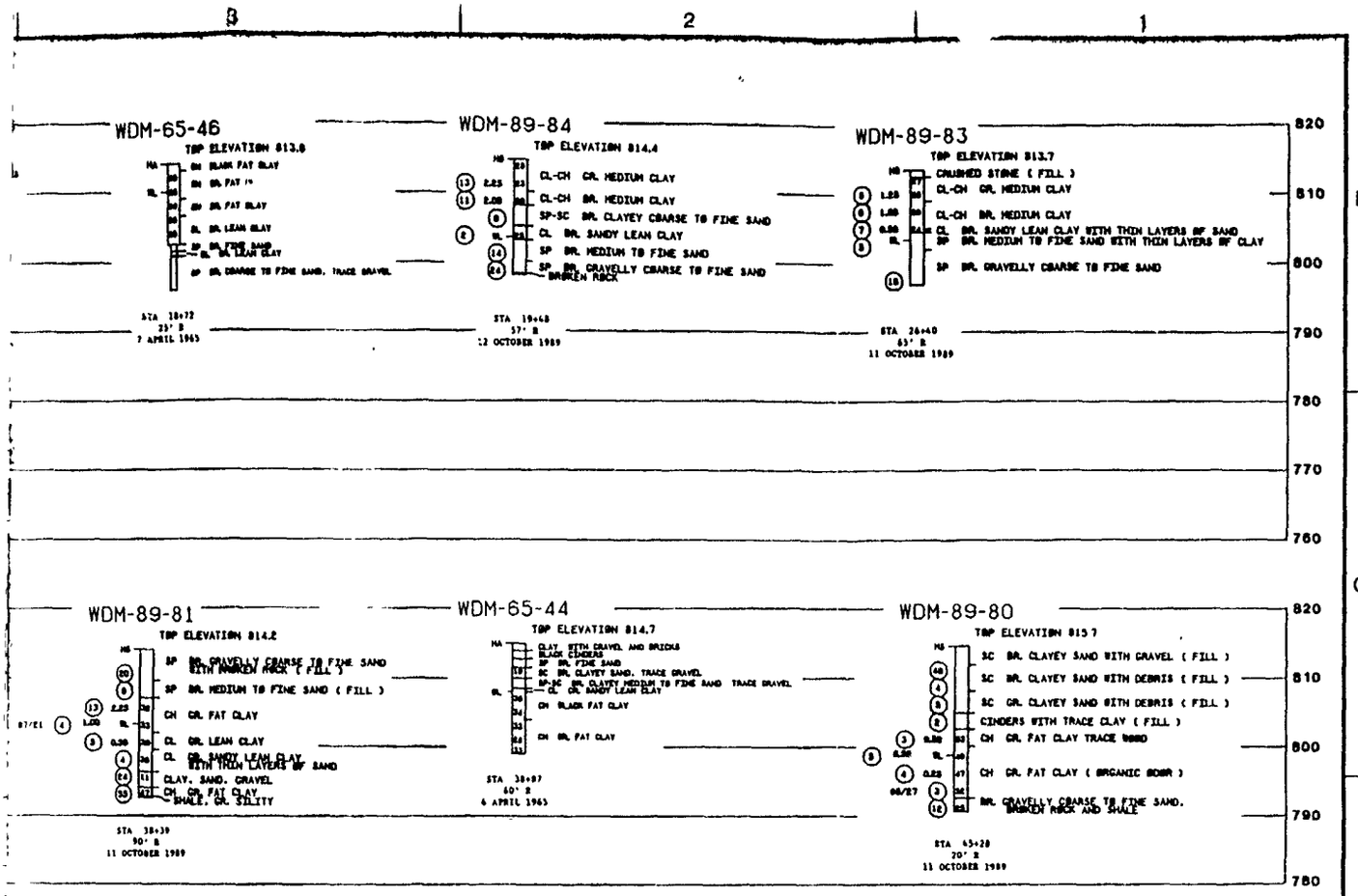

5
4
3
D
C
B
A
N
DOUGLAS AVE. DISPOSAL SITE
DES MOINES
WEST DES MOINES
GRAND AVE.
PROJECT LOCATION
GRAND AVE. BORROW AREA
WALNUT WOODS
BOONE RD.
VALLEY

(A)

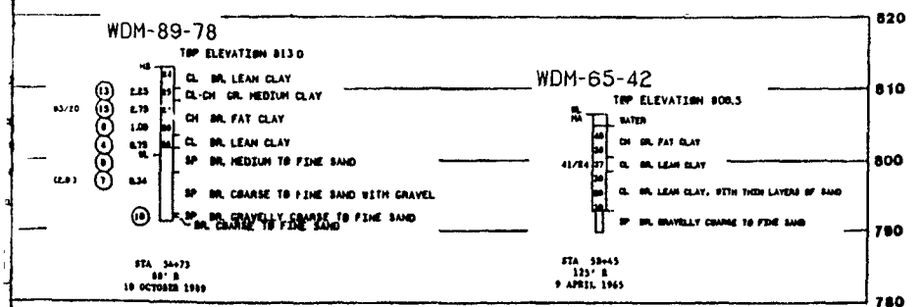

3
2
1
D
C
B
A
DOUGLAS AVE
DISPOSAL SITE
DES MOINES
PIONEER PARK
BORROW AREA
LOCATION
SCALE 1"=2000'
0' 2000' 4000' 6000'
U S ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION
DISPOSAL SITE AND BORROW AREAS
PLATE 28

(B)


5
4
3
D
C
B
A
820
810
800
790
780
770
760
WDM-89-85
TBP ELEVATION 814.8
CL GR. SANDY LEAN CLAY
CL-CH GR. MEDIUM CLAY
CL BR LEAN CLAY
SP-SC BR. CLAYEY COARSE TO FINE SAND
SP SC BR. CLAYEY COARSE TO FINE SAND WITH GRAVEL
SP BR. GRAVELLY MEDIUM TO FINE SAND
SP GR MEDIUM TO FINE SAND
SP SC BR CLAYEY GRAVELLY COARSE TO FINE SAND
SHALE GR. SILTY FRIABLE
STA 13+66
6' R
12 OCTOBER 1989
WDM-65-47
TBP ELEVATION 817.0
CLAY AND ROAD GRAVEL
CL BR. LEAN CLAY, TRACE GRAVEL
CL BR. VERY LEAN CLAY
CL-CH BR. SANDY MEDIUM CLAY, TRACE PEBBLES
CH BR. FAT CLAY
CL-CH BR. MEDIUM CLAY
CL BR. SANDY LEAN CLAY
SP BR. MEDIUM TO FINE SAND
CL BR. SANDY LEAN CLAY
SP-SC BR. CLAYEY MEDIUM TO FINE SAND
SP BR. GRAVELLY COARSE TO FINE SAND
STA 17+65
375' L
7 APRIL 1965
WDM-65-46
TBP ELEVATION 813.8
BR BLACK FAT CLAY
CH BR. FAT CLAY
CH BR. FAT CLAY
CL BR. LEAN CLAY
CL BR. LEAN CLAY
SP BR. COARSE TO FINE SAND TRACE GRAVEL
STA 18+72
25' R
7 APRIL 1965
WDM-89-8
TBP
STA 19+48
52' R
12 OCTOBER 19
WDM-65-45
TBP ELEVATION 812.6
CH GR. FAT CLAY
CL CH BR. MEDIUM CLAY
CL BR. LEAN CLAY
CL CH BR. MEDIUM CLAY
CH GR. FAT CLAY
SP GR. GRAVELLY COARSE TO FINE SAND
STA 28+72
33' R
7 APRIL 1965
WDM-89-82
TBP ELEVATION 812.8
SC BR. CLAYEY SAND WITH CRUSHED STONE (FILL)
CL-CH BR. MEDIUM CLAY
CL BR. SANDY LEAN CLAY
CL BR. LEAN CLAY
SP-SC BR. CLAYEY MEDIUM TO FINE SAND WITH THIN LAYERS OF CLAY
BROKEN ROCK
STA 34+54
82' R
11 OCTOBER 1989
WDM-89-81
TBP ELEVATION 814.2
SP BR. GRAVELLY COARSE TO FINE SAND WITH BROKEN ROCK (FILL)
SP BR. MEDIUM TO FINE SAND (FILL)
CH GR. FAT CLAY
CL GR. LEAN CLAY
CL GR. SANDY LEAN CLAY WITH THIN LAYERS OF SAND
CLAY, SAND, GRAVEL
CH GR. FAT CLAY
SHALE, GR. SILTY
STA 38+39
90' R
1. OCTOBER 1989
WDM-65-4
TBP
STA 38+87
60' R
6 APRIL 1965
WDM-65-43
TBP ELEVATION 813.9
WHITE WASTE RUBBER AND CONCRETE
RUBBLE (CLAY, SAND, GRAVEL, GLASS AND WOOD)
NO WATER LEVEL ENCOUNTERED
STA 49+00
5' R
6 APRIL 1965
WDM-89-79
TBP ELEVATION 810.8
CL GR. SANDY LEAN CLAY (FILL)
CL GR. SANDY LEAN CLAY WITH DEBRIS (FILL)
CL GR. SANDY LEAN CLAY WITH THIN LAYERS OF SAND
CH GR. FAT CLAY WITH WOOD
CH GR. FAT CLAY
SP GR. MEDIUM TO FINE SAND
SHALE, GR. MOTTLED RED AND YELLOW
STA 51+27
70' R
11 OCTOBER 1989
WDM-89-78
TBP ELEVATION 813.0
CL BR. LEAN CLAY
CL-CH GR. MEDIUM CLAY
CH BR. FAT CLAY
CL BR. LEAN CLAY
SP BR. MEDIUM TO FINE SAND
SP BR. COARSE TO FINE SAND WITH GRAVEL
SP BR. GRAVELLY COARSE TO FINE SAND
BR. COARSE TO FINE SAND
STA 34+73
88' R
10 OCTOBER 1989
WDM
(A)



REFERENCE:
FOR LOCATION OF BORINGS
SEE PLATES 5, 6, 7 & 8



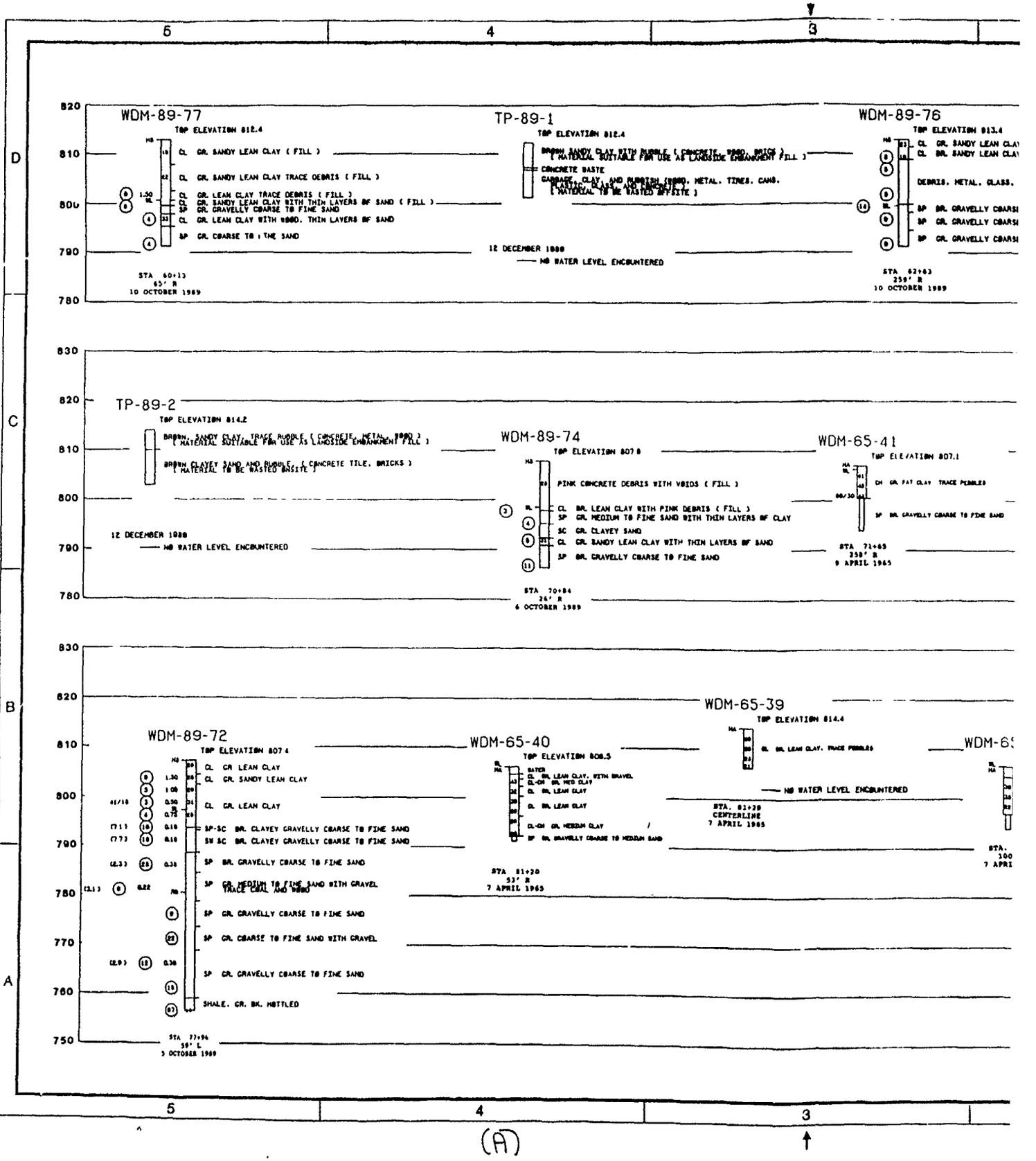
Revisions			
Symbol	Descriptions	Date	Approved

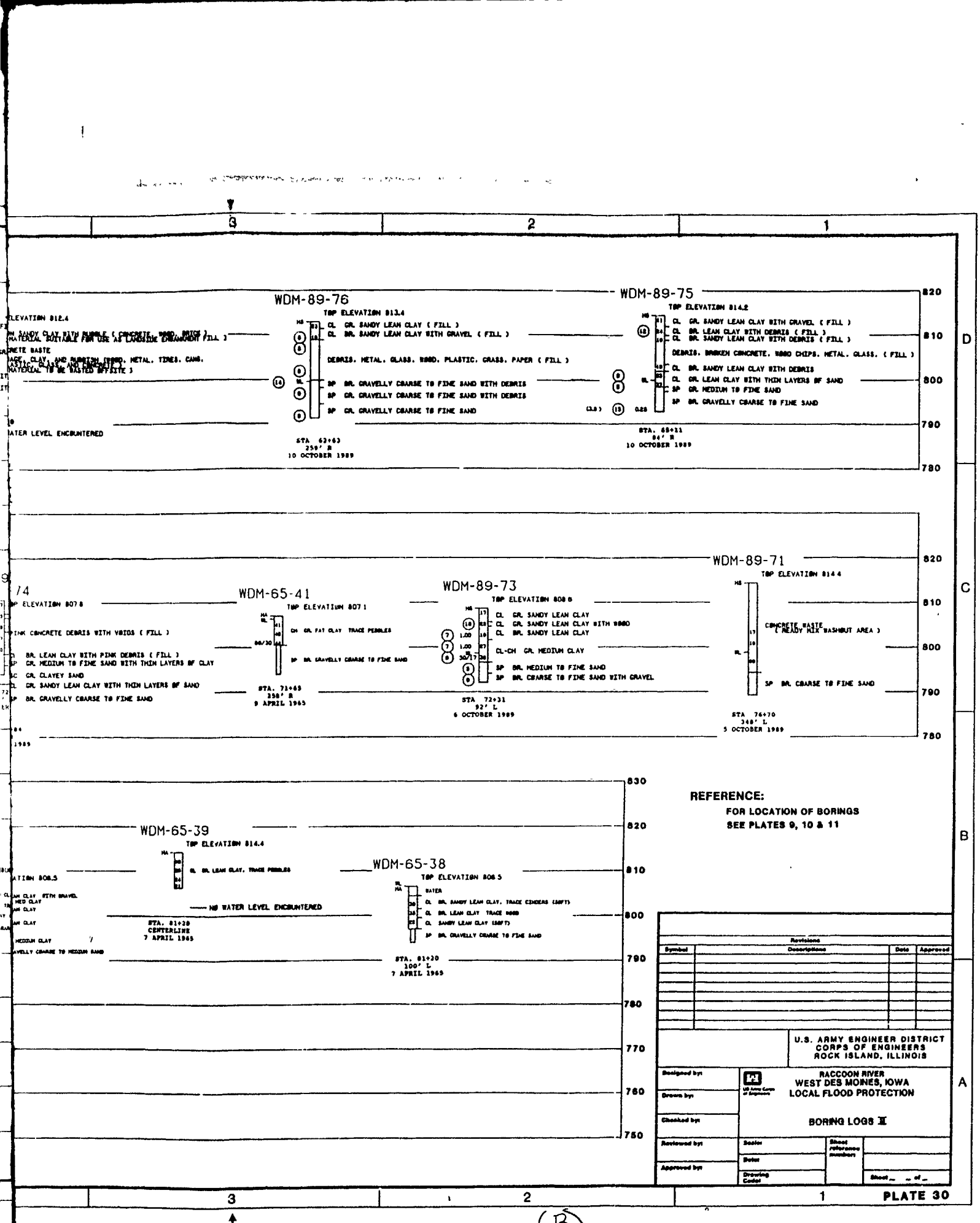
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:	RACCOON RIVER WEST DES MOINES, IOWA LOCAL FLOOD PROTECTION
Drawn by:	
Checked by:	BORING LOGS I
Reviewed by:	Scale: / Sheet reference number:
Approved by:	Date: / Drawing Code: / Sheet ... of ...

PLATE 29

(B)


5
4
3
D
C
B
A
WDM-89-77
TOP ELEVATION 812.4
CL GR. SANDY LEAN CLAY (FILL)
CL GR. SANDY LEAN CLAY TRACE DEBRIS (FILL)
CL GR. LEAN CLAY TRACE DEBRIS (FILL)
CL GR. SANDY LEAN CLAY WITH THIN LAYERS OF SAND (FILL)
SP GR. GRAVELLY COARSE TO FINE SAND
CL GR. LEAN CLAY WITH WOOD, THIN LAYERS OF SAND
SP GR. COARSE TO FINE SAND
STA 60+13
65' R
10 OCTOBER 1989
TP-89-1
TOP ELEVATION 812.4
BROWN SANDY CLAY WITH RUBBLE (CONCRETE, WOOD, BRICK)
(MATERIAL SUITABLE FOR USE AS LANDSIDE EMBANKMENT FILL)
CONCRETE WASTE
GARBAGE, CLAY, AND RUBBISH (WOOD, METAL, TIRES, CANS, PLASTIC, GLASS, AND RUBBISH)
(MATERIAL TO BE WASTED OFFSITE)
12 DECEMBER 1989
NO WATER LEVEL ENCOUNTERED
WDM-89-76
TOP ELEVATION 813.4
CL GR. SANDY LEAN CLAY
CL BR. SANDY LEAN CLAY
DEBRIS, METAL, GLASS,
SP BR. GRAVELLY COARSE
SP GR. GRAVELLY COARSE
SP GR. GRAVELLY COARSE
STA 62+63
259' R
10 OCTOBER 1989
TP-89-2
TOP ELEVATION 814.2
BROWN, SANDY CLAY, TRACE RUBBLE (CONCRETE, METAL, WOOD)
(MATERIAL SUITABLE FOR USE AS LANDSIDE EMBANKMENT FILL)
BROWN CLAYEY SAND AND RUBBLE (CONCRETE TILE, BRICKS)
(MATERIAL TO BE WASTED OFFSITE)
12 DECEMBER 1989
NO WATER LEVEL ENCOUNTERED
WDM-89-74
TOP ELEVATION 807.8
PINK CONCRETE DEBRIS WITH VOIDS (FILL)
CL BR. LEAN CLAY WITH PINK DEBRIS (FILL)
SP GR. MEDIUM TO FINE SAND WITH THIN LAYERS OF CLAY
SC GR. CLAYEY SAND
CL GR. SANDY LEAN CLAY WITH THIN LAYERS OF SAND
SP BR. GRAVELLY COARSE TO FINE SAND
STA 70+84
26' R
6 OCTOBER 1989
WDM-65-41
TOP ELEVATION 807.1
CH GR. FAT CLAY TRACE PEBBLES
SP BR. GRAVELLY COARSE TO FINE SAND
STA 71+65
258' R
9 APRIL 1965
WDM-89-72
TOP ELEVATION 807.4
CL GR LEAN CLAY
CL GR. SANDY LEAN CLAY
CL GR. LEAN CLAY
SP-SC BR. CLAYEY GRAVELLY COARSE TO FINE SAND
SW SC BR. CLAYEY GRAVELLY COARSE TO FINE SAND
SP BR. GRAVELLY COARSE TO FINE SAND
SP GR. MEDIUM TO FINE SAND WITH GRAVEL TRACE CAL AND WOOD
SP GR. GRAVELLY COARSE TO FINE SAND
SP GR. COARSE TO FINE SAND WITH GRAVEL
SP GR. GRAVELLY COARSE TO FINE SAND
SHALE, GR. BK. MOTTLED
STA 77+96
59' L
3 OCTOBER 1989
WDM-65-40
TOP ELEVATION 808.5
WATER
CL GR. LEAN CLAY, WITH GRAVEL
CL-CH BR. MED CLAY
CL BR. LEAN CLAY
CL BR. LEAN CLAY
CL-CH GR. MEDIUM CLAY
SP BR. GRAVELLY COARSE TO MEDIUM SAND
STA 81+20
53' R
7 APRIL 1965
WDM-65-39
TOP ELEVATION 814.4
CL BR. LEAN CLAY, TRACE PEBBLES
NO WATER LEVEL ENCOUNTERED
STA. 81+20
CENTERLINE
7 APRIL 1965
WDM-65
STA. 100
7 APRI
(A)



REFERENCE:
FOR LOCATION OF BORINGS
SEE PLATES 9, 10 & 11

Revisions			
Symbol	Descriptions	Date	Approved

U.S. ARMY ENGINEER DISTRICT
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ROCK ISLAND, ILLINOIS

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Checked by:
Reviewed by:
Approved by:

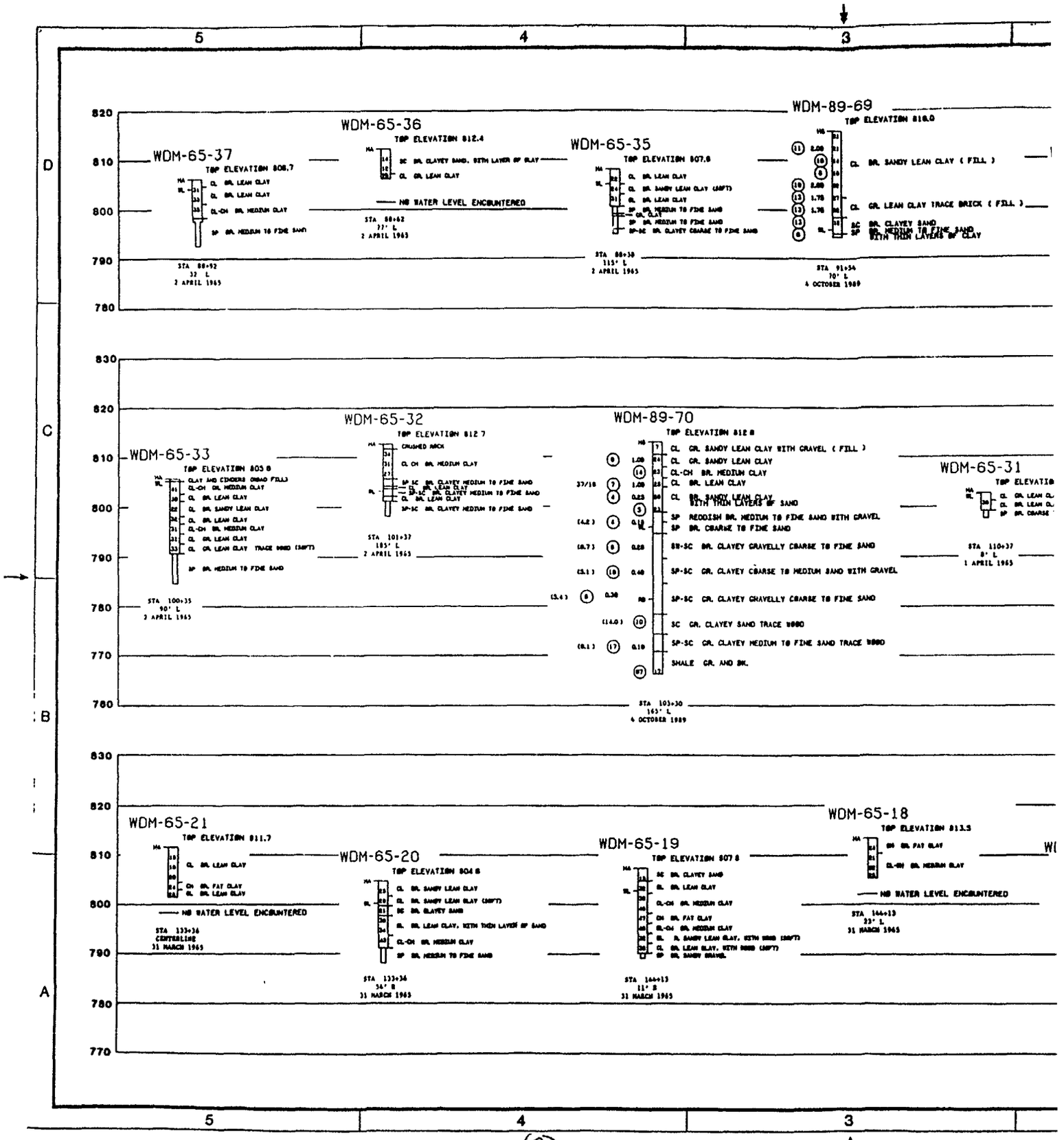
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

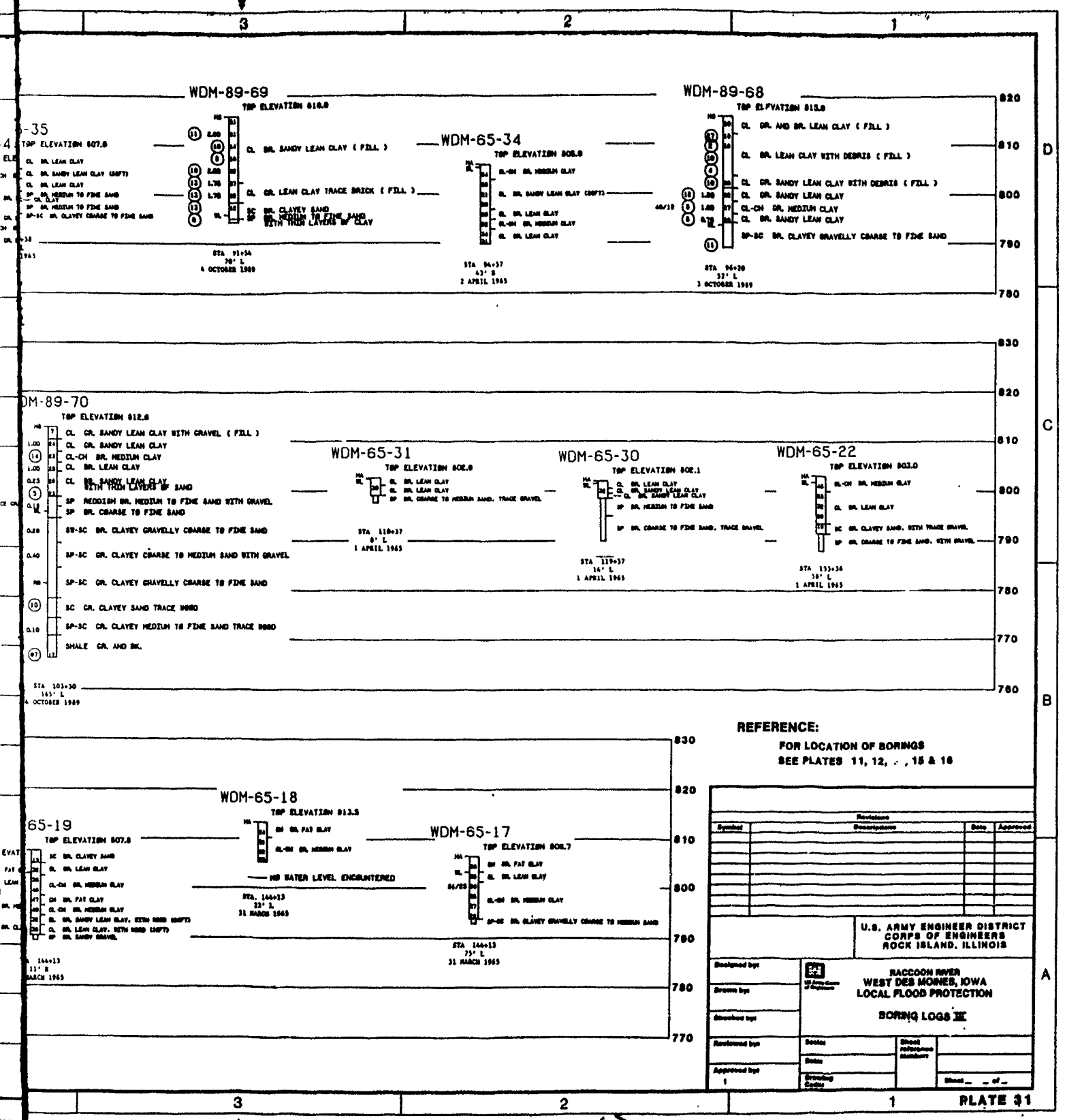
BORING LOGS II

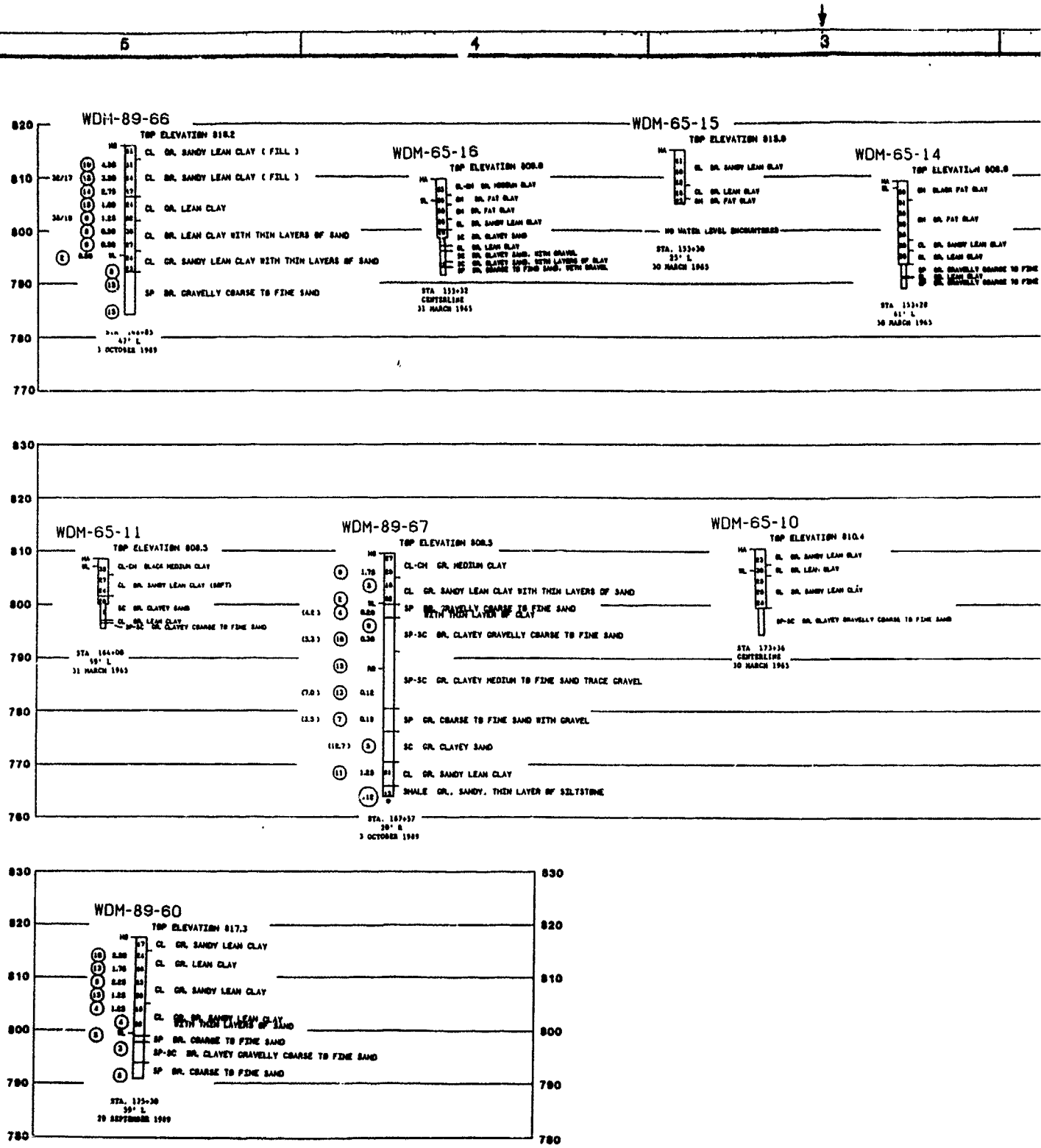
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Sheet reference numbers:
Sheet _ of _

PLATE 30

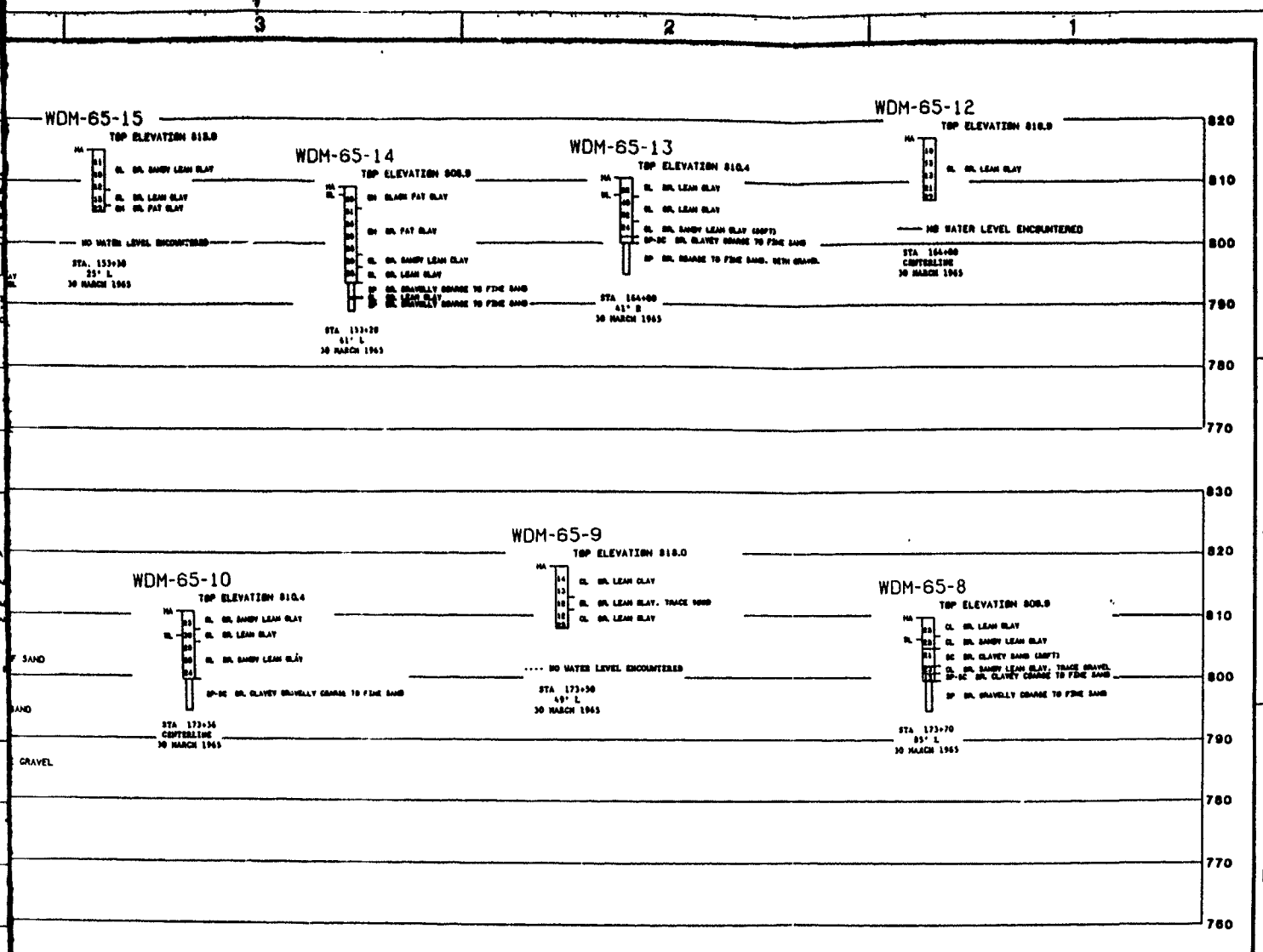
(B)


5
4
3
D
C
B
A
820
810
800
790
780
830
770
WDM-65-37
T&P ELEVATION 808.7
CL BR. LEAN CLAY
CL BR. LEAN CLAY
CL-CH BR. MEDIUM CLAY
SP BR. MEDIUM TO FINE SAND
STA 88+92
32' L
2 APRIL 1965
WDM-65-36
T&P ELEVATION 812.4
SC BR. CLAYEY SAND, WITH LAYER OF CLAY
CL BR. LEAN CLAY
NO WATER LEVEL ENCOUNTERED
STA 88+62
27' L
2 APRIL 1965
WDM-65-35
T&P ELEVATION 807.6
CL BR. LEAN CLAY
CL BR. SANDY LEAN CLAY (SOFT)
CL BR. LEAN CLAY
SP BR. MEDIUM TO FINE SAND
GR. CLAY
SP-SC BR. CLAYEY COARSE TO FINE SAND
STA 88+38
115' L
2 APRIL 1965
WDM-89-69
T&P ELEVATION 818.0
CL BR. SANDY LEAN CLAY (FILL)
CL GR. LEAN CLAY TRACE BRICK (FILL)
SC BR. CLAYEY SAND
SP BR. MEDIUM TO FINE SAND WITH THIN LAYERS OF CLAY
STA 91+56
70' L
4 OCTOBER 1989
WDM-65-33
T&P ELEVATION 805.8
CLAY AND CINDERS (ROAD FILL)
CL-CH BR. MEDIUM CLAY
CL BR. LEAN CLAY
CL BR. SANDY LEAN CLAY
CL BR. LEAN CLAY
CL-CH BR. MEDIUM CLAY
CL BR. LEAN CLAY
CL GR. LEAN CLAY TRACE WOOD (SOFT)
SP BR. MEDIUM TO FINE SAND
STA 100+35
90' L
2 APRIL 1965
WDM-65-32
T&P ELEVATION 812.7
CRUSHED ROCK
CL CH BR. MEDIUM CLAY
SP-SC BR. CLAYEY MEDIUM TO FINE SAND
CL BR. LEAN CLAY
SP-SC BR. CLAYEY MEDIUM TO FINE SAND
CL BR. LEAN CLAY
SP-SC BR. CLAYEY MEDIUM TO FINE SAND
STA 101+37
185' L
2 APRIL 1965
WDM-89-70
T&P ELEVATION 812.8
CL GR. SANDY LEAN CLAY WITH GRAVEL (FILL)
CL GR. SANDY LEAN CLAY
CL-CH BR. MEDIUM CLAY
CL BR. LEAN CLAY
CL BR. SANDY LEAN CLAY WITH THIN LAYERS OF SAND
SP REDDISH BR. MEDIUM TO FINE SAND WITH GRAVEL
SP BR. COARSE TO FINE SAND
SW-SC BR. CLAYEY GRAVELLY COARSE TO FINE SAND
SP-SC GR. CLAYEY COARSE TO MEDIUM SAND WITH GRAVEL
SP-SC GR. CLAYEY GRAVELLY COARSE TO FINE SAND
SC GR. CLAYEY SAND TRACE WOOD
SP-SC GR. CLAYEY MEDIUM TO FINE SAND TRACE WOOD
SHALE GR. AND BK.
STA 103+30
163' L
4 OCTOBER 1989
WDM-65-31
T&P ELEVATIO
CL GR. LEAN CL
CL BR. LEAN CL
SP BR. COARSE
STA 110+37
8' L
1 APRIL 1965
WDM-65-21
T&P ELEVATION 811.7
CL BR. LEAN CLAY
CH BR. FAT CLAY
CL BR. LEAN CLAY
NO WATER LEVEL ENCOUNTERED
STA 133+36
CENTERLINE
31 MARCH 1965
WDM-65-20
T&P ELEVATION 804.8
CL BR. SANDY LEAN CLAY
CL BR. SANDY LEAN CLAY (SOFT)
SC BR. CLAYEY SAND
SL BR. LEAN CLAY, WITH THIN LAYER OF SAND
CL-CH BR. MEDIUM CLAY
SP BR. MEDIUM TO FINE SAND
STA 133+36
54' R
31 MARCH 1965
WDM-65-19
T&P ELEVATION 807.8
SC BR. CLAYEY SAND
SL BR. LEAN CLAY
CL-CH BR. MEDIUM CLAY
CH BR. FAT CLAY
CL-CH BR. MEDIUM CLAY
SL BR. SANDY LEAN CLAY, WITH WOOD (SOFT)
CL BR. LEAN CLAY, WITH WOOD (SOFT)
SP BR. SANDY GRAVEL
STA 166+13
11' R
31 MARCH 1965
WDM-65-18
T&P ELEVATION 813.5
SM BR. FAT CLAY
CL-CH BR. MEDIUM CLAY
NO WATER LEVEL ENCOUNTERED
STA 166+13
23' L
31 MARCH 1965
(A)


3
2
1
WDM-89-69
TOP ELEVATION 816.0
CL BR. SANDY LEAN CLAY (FILL)
CL GR. LEAN CLAY TRACE BRICK (FILL)
SC BR. CLAYEY SAND
SP BR. MEDIUM TO FINE SAND WITH THIN LAYERS OF CLAY
STA 91+54
70' L
4 OCTOBER 1989
WDM-65-34
TOP ELEVATION 808.0
STA 94+57
43' R
2 APRIL 1965
WDM-89-68
TOP ELEVATION 813.0
CL GR. AND BR. LEAN CLAY (FILL)
CL GR. LEAN CLAY WITH DEBRIS (FILL)
CL GR. SANDY LEAN CLAY WITH DEBRIS (FILL)
CL BR. SANDY LEAN CLAY
CL-CH GR. MEDIUM CLAY
CL GR. SANDY LEAN CLAY
SP-SC BR. CLAYEY GRAVELLY COARSE TO FINE SAND
STA 96+20
32' L
3 OCTOBER 1989
820
810
800
790
780
D
WDM-89-70
TOP ELEVATION 812.8
CL GR. SANDY LEAN CLAY WITH GRAVEL (FILL)
CL GR. SANDY LEAN CLAY
CL-CH BR. MEDIUM CLAY
CL BR. LEAN CLAY
CL BR. SANDY LEAN CLAY WITH THIN LAYERS OF SAND
SP REDDISH BR. MEDIUM TO FINE SAND WITH GRAVEL
SP BR. COARSE TO FINE SAND
SW-SC BR. CLAYEY GRAVELLY COARSE TO FINE SAND
SP-SC GR. CLAYEY COARSE TO MEDIUM SAND WITH GRAVEL
SP-SC GR. CLAYEY GRAVELLY COARSE TO FINE SAND
SC GR. CLAYEY SAND TRACE WOOD
SP-SC GR. CLAYEY MEDIUM TO FINE SAND TRACE WOOD
SHALE GR. AND BK.
STA 103+30
163' L
4 OCTOBER 1989
WDM-65-31
TOP ELEVATION 806.6
CL BR. LEAN CLAY
CL BR. LEAN CLAY
SP BR. COARSE TO MEDIUM SAND, TRACE GRAVEL
STA 110+37
8' L
1 APRIL 1965
WDM-65-30
TOP ELEVATION 806.1
CL BR. LEAN CLAY
CL BR. SANDY LEAN CLAY
SP BR. MEDIUM TO FINE SAND
SP BR. COARSE TO FINE SAND, TRACE GRAVEL
STA 119+57
14' L
1 APRIL 1965
WDM-65-22
TOP ELEVATION 803.0
CL-CH BR. MEDIUM CLAY
CL BR. LEAN CLAY
SC GR. CLAYEY SAND, WITH TRACE GRAVEL
SP GR. COARSE TO FINE SAND, WITH GRAVEL
STA 133+36
38' L
1 APRIL 1965
830
820
810
800
790
780
770
760
C
B
WDM-65-18
TOP ELEVATION 813.3
CH BR. FAT CLAY
CL-CH BR. MEDIUM CLAY
NO WATER LEVEL ENCOUNTERED
STA. 144+13
23' L
31 MARCH 1965
WDM-65-17
TOP ELEVATION 808.7
CH BR. FAT CLAY
CL BR. LEAN CLAY
CL-CH BR. MEDIUM CLAY
SP-SC BR. CLAYEY GRAVELLY COARSE TO MEDIUM SAND
STA 144+13
75' L
31 MARCH 1965
65-19
TOP ELEVATION 807.8
SC BR. CLAYEY SAND
CL BR. LEAN CLAY
CL-CH BR. MEDIUM CLAY
CH BR. FAT CLAY
CL-CH BR. MEDIUM CLAY
CL BR. SANDY LEAN CLAY, WITH WOOD (SOFT)
CL GR. LEAN CLAY, WITH WOOD (SOFT)
SP BR. SANDY GRAVEL
144+13
11' R
MARCH 1965
830
820
810
800
790
780
770
A
REFERENCE:
FOR LOCATION OF BORINGS
SEE PLATES 11, 12, . , 15 & 16
Revisions
Symbol
Description
Date
Approved
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS
Designed by
Drawn by
Checked by
Reviewed by
Approved by
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION
BORING LOGS IX
Scale
Date
Drawing Code
Sheet reference numbers
Sheet _ of _
3
2
1
PLATE 31


5
4
3
D
C
B
A
WDM-89-66
TOP ELEVATION 818.2
CL GR. SANDY LEAN CLAY (FILL)
CL GR. SANDY LEAN CLAY (FILL)
CL GR. LEAN CLAY
CL GR. LEAN CLAY WITH THIN LAYERS OF SAND
CL GR. SANDY LEAN CLAY WITH THIN LAYERS OF SAND
SP GR. GRAVELLY COARSE TO FINE SAND
3 OCTOBER 1989
WDM-65-16
TOP ELEVATION 808.8
CL-CH GR. MEDIUM CLAY
CH GR. FAT CLAY
CH GR. FAT CLAY
CL GR. SANDY LEAN CLAY
SC GR. CLAYEY SAND
CL GR. LEAN CLAY
SC GR. CLAYEY SAND, WITH GRAVEL
CL GR. CLAYEY SAND, WITH LAYERS OF CLAY
SP GR. COARSE TO FINE SAND, WITH GRAVEL
STA 153+32
CENTERLINE
31 MARCH 1965
WDM-65-15
TOP ELEVATION 818.8
CL GR. SANDY LEAN CLAY
CL GR. LEAN CLAY
CH GR. FAT CLAY
NO WATER LEVEL ENCOUNTERED
STA. 153+30
25' L
30 MARCH 1965
WDM-65-14
TOP ELEVATION 808.8
CH BLACK FAT CLAY
CH GR. FAT CLAY
CL GR. SANDY LEAN CLAY
CL GR. LEAN CLAY
STA 153+28
61' L
30 MARCH 1965
WDM-65-11
TOP ELEVATION 808.5
CL-CH BLACK MEDIUM CLAY
CL GR. SANDY LEAN CLAY (SOFT)
SC GR. CLAYEY SAND
CL GR. LEAN CLAY
STA 164+08
59' L
31 MARCH 1965
WDM-89-67
TOP ELEVATION 808.5
CL-CH GR. MEDIUM CLAY
CL GR. SANDY LEAN CLAY WITH THIN LAYERS OF SAND
SP GR. GRAVELLY COARSE TO FINE SAND WITH THIN LAYER OF CLAY
SP-SC GR. CLAYEY GRAVELLY COARSE TO FINE SAND
SP-SC GR. CLAYEY MEDIUM TO FINE SAND TRACE GRAVEL
SP GR. COARSE TO FINE SAND WITH GRAVEL
SC GR. CLAYEY SAND
CL GR. SANDY LEAN CLAY
SHALE GR., SANDY, THIN LAYER OF SILTSTONE
STA. 167+57
39' R
3 OCTOBER 1989
WDM-65-10
TOP ELEVATION 810.4
CL GR. SANDY LEAN CLAY
CL GR. LEAN CLAY
CL GR. SANDY LEAN CLAY
SP-SC GR. CLAYEY GRAVELLY COARSE TO FINE SAND
STA 173+36
CENTERLINE
30 MARCH 1965
WDM-89-60
TOP ELEVATION 817.3
CL GR. SANDY LEAN CLAY
CL GR. LEAN CLAY
CL GR. SANDY LEAN CLAY
CL GR. SANDY LEAN CLAY WITH THIN LAYERS OF SAND
SP GR. COARSE TO FINE SAND
SP-SC GR. CLAYEY GRAVELLY COARSE TO FINE SAND
SP GR. COARSE TO FINE SAND
STA. 125+30
39' L
29 SEPTEMBER 1989
820
810
800
790
780
770
830

(A)



REFERENCE:

FOR LOCATION OF BORINGS SEE PLATES 16, 17 & 18

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
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ROCK ISLAND, ILLINOIS

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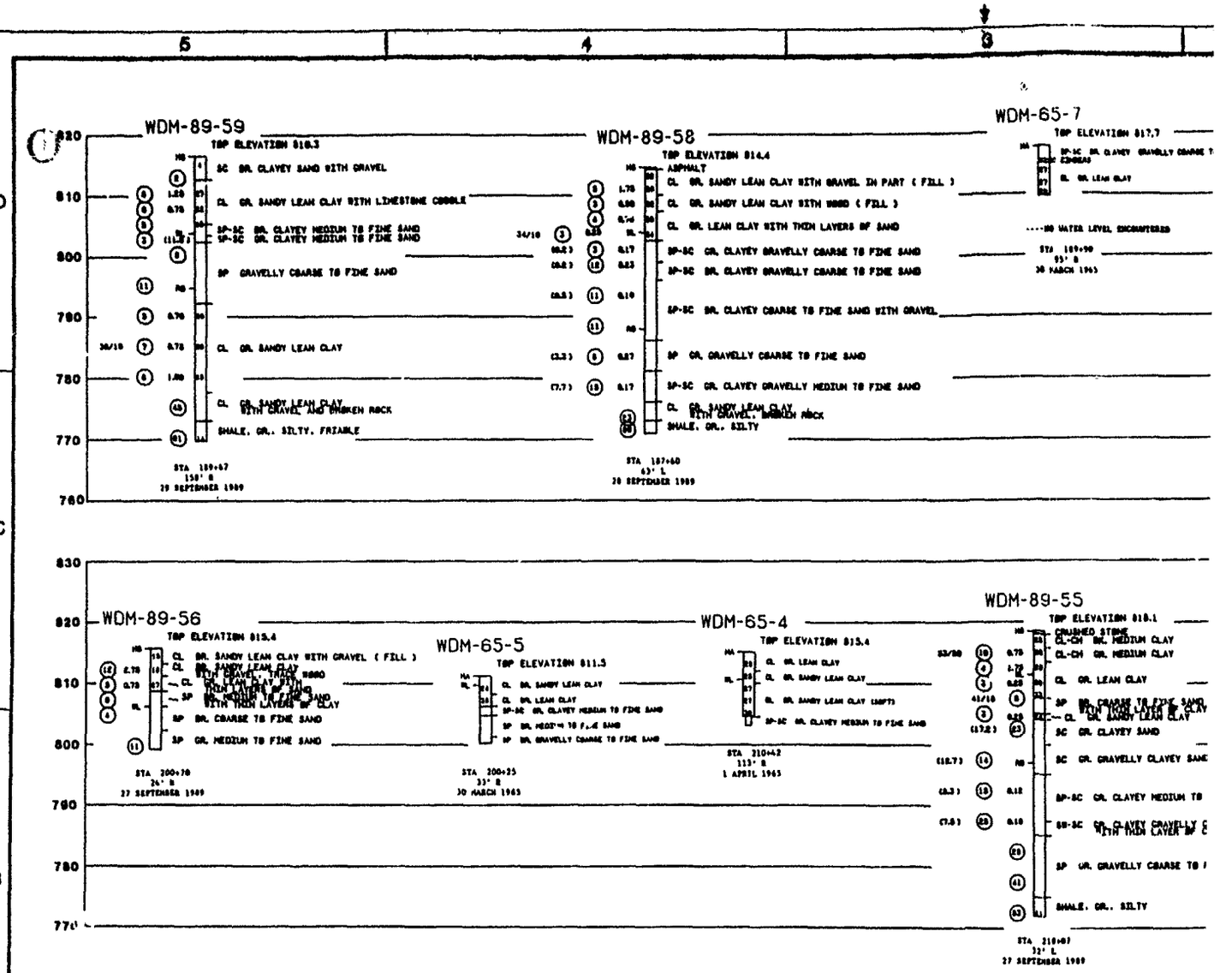
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

BORING LOGS IX

Scale
Date
Drawing Code
Sheet reference numbers
Sheet __ of __

PLATE 32

(B)



*UNIFIED SOIL CLASSIFICATION

MAJOR DIVISIONS		TYPE	LETTER SYMBOL	TYPICAL NAMES
COARSE GRAINED SOILS >50% OF MATERIAL IS RETAINED ON #200 SIEVE	GRAVELS >50% OF COARSE FRACTION IS RETAINED ON #4 SIEVE	CLEAN GRAVELS	GW	GRAVEL, WELL GRADED, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			GP	GRAVEL, POORLY GRADED, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES	GM	SILTY GRAVEL, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVEL, GRAVEL-SAND-CLAY MIXTURES
	SANDS >50% OF COARSE FRACTION PASSES #4 SIEVE	CLEAN SANDS	SW	SAND, WELL GRADED, GRAVELLY SANDS
			SP	SAND, POORLY GRADED, GRAVELLY SANDS
		SANDS WITH FINES	SM	SILTY SAND, SAND-SILT MIXTURES
			SC	CLAYEY SAND, SAND-CLAY MIXTURES
FINE GRAINED SOILS >50% OF MATERIAL PASSES A #200 SIEVE		SILTS AND CLAYS LL<50	ML	SILT & VERY FINE SAND, SILTY OR CLAYEY FINE SAND OR CLAYEY SILT
			CL	LEAN CLAY, SANDY CLAY, SILTY CLAY, OF LOW TO MEDIUM PLASTICITY
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
		SILTS AND CLAYS LL>50	MH	SILT, FINE SANDY OR SILTY SOIL WITH HIGH PLASTICITY
			CH	FAT CLAY, INORGANIC CLAY OF HIGH PLASTICITY
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, AND HIGHLY ORGANIC SOIL

* THE CLASSIFICATION OF SOILS IS IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM BRIEFLY PRESENTED IN THE TABLE ABOVE. FOR A COMPLETE DESCRIPTION OF THE UNIFIED SOIL CLASSIFICATION SYSTEM REFER TO: TECHNICAL MEMORANDUM NO. 3-357 PREPARED BY THE U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS, VICKSBURG, MISSISSIPPI.

LEGEND

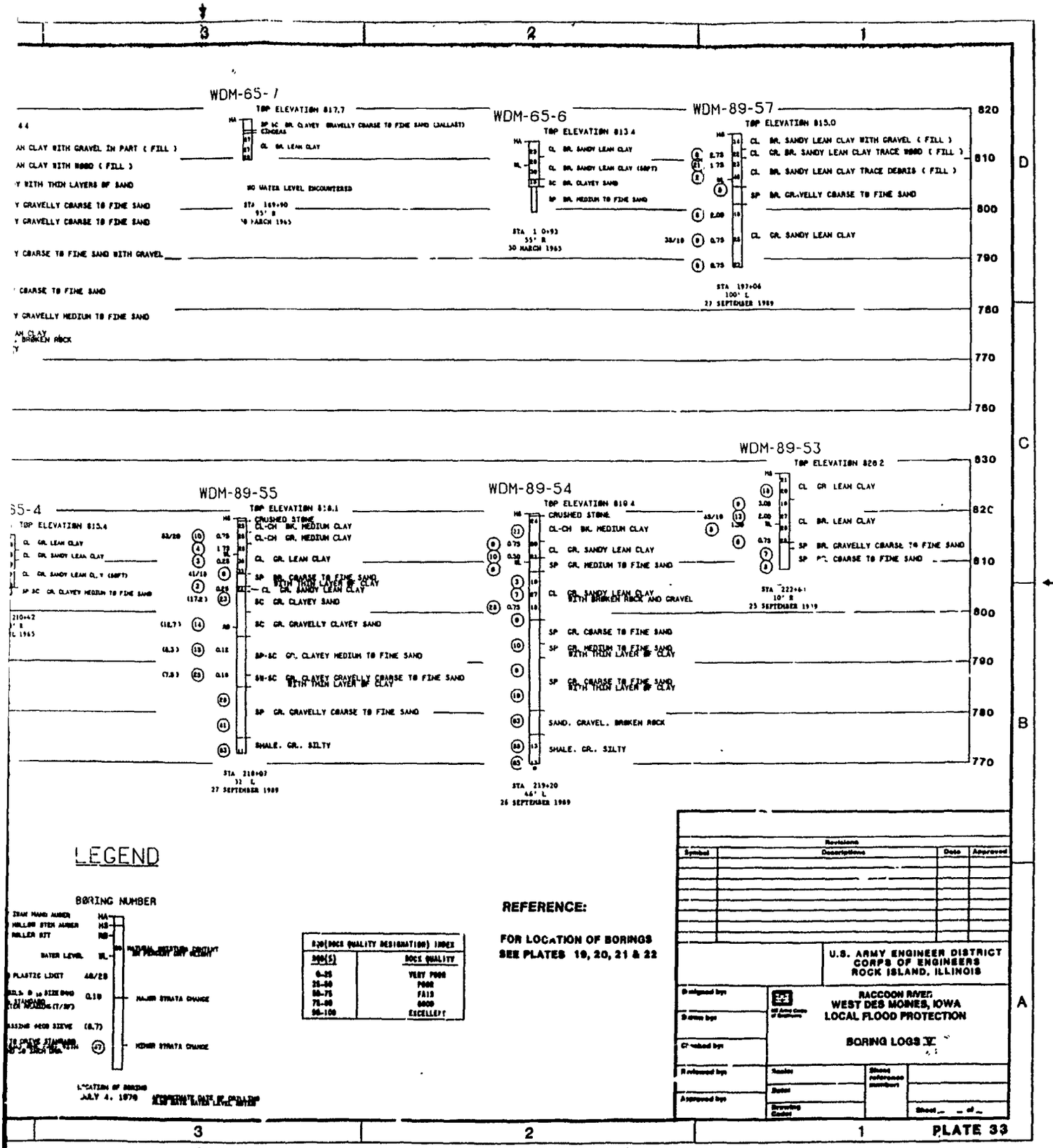
BORING NUMBER

HOLE ADVANCED BY HAND HAND AUGER	HA
HOLE ADVANCED BY ROLLER BIT	RB
WATER LEVEL	WL
LIQUID AND PLASTIC LIMIT	48/28
PERCENT PASSING #200 SIEVE	(8.7)

ROCK QUALITY
RQD(%)
0-25
25-50
50-75
75-90
90-100

LOCATION OF BORING
JULY 4, 1870

(A)



LEGEND

BORING NUMBER

RQD(%)	ROCK QUALITY
0-25	VERY POOR
25-50	POOR
50-75	FAIR
75-90	GOOD
90-100	EXCELLENT

REFERENCE:

FOR LOCATION OF BORINGS SEE PLATES 19, 20, 21 & 22

Revisions			
Symbol	Descriptions	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

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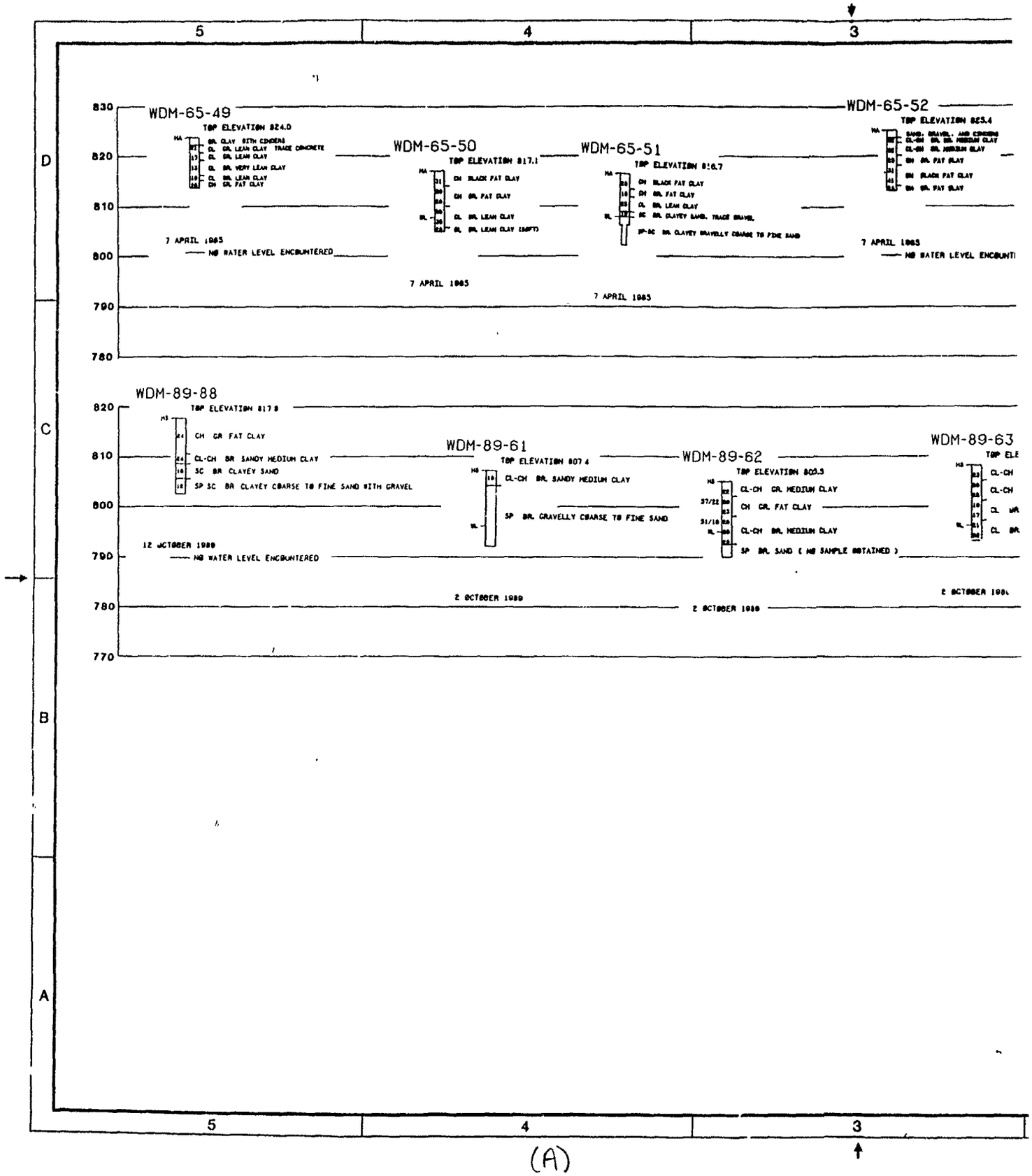
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

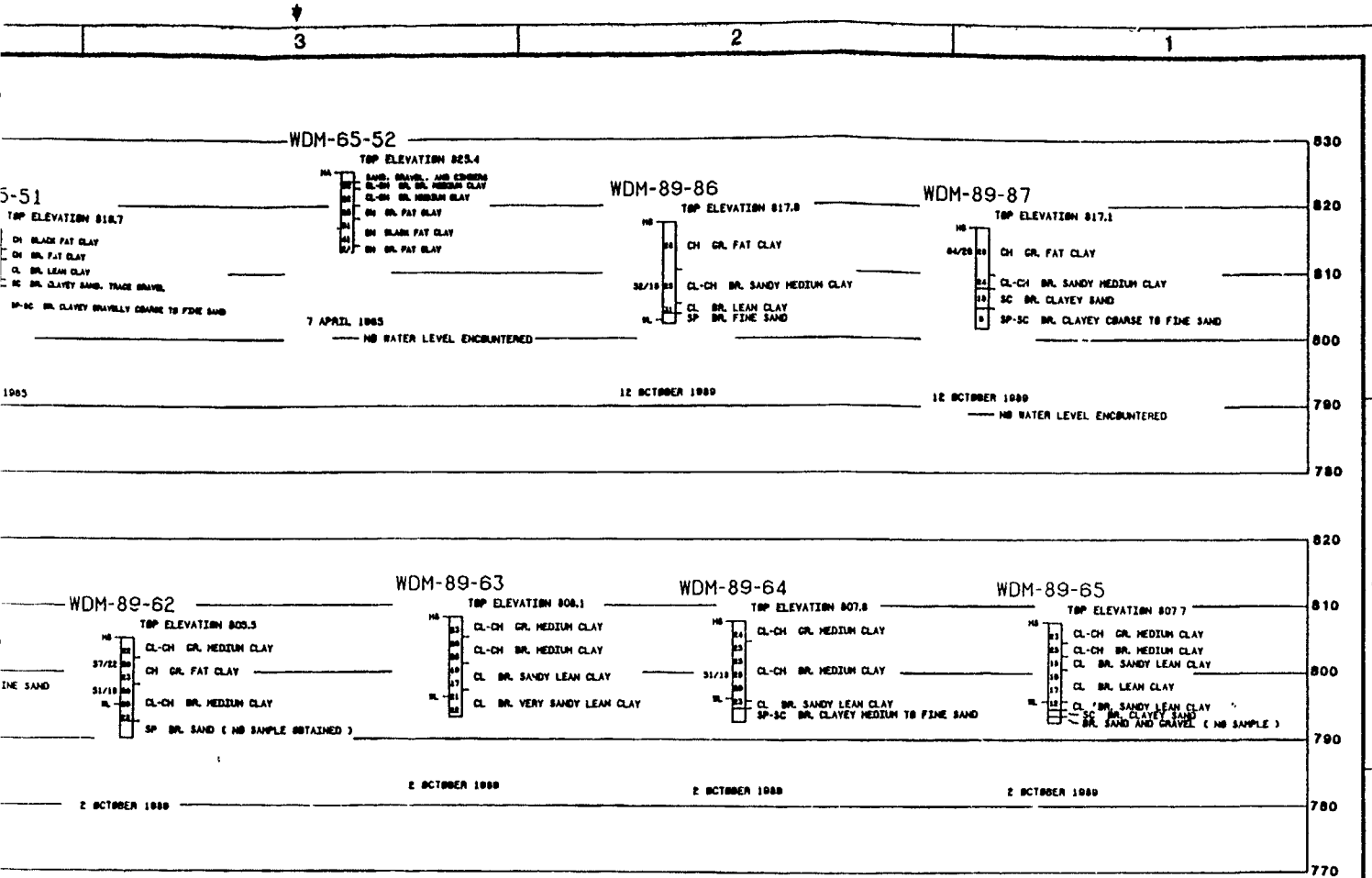
BORING LOGS IX

Scale
Date
Drawing Code
Sheet reference number
Sheet __ of __

PLATE 33

(B)


5
4
3
D
C
B
A
830
820
810
800
790
780
WDM-65-49
TOP ELEVATION 824.0
WDM-65-50
TOP ELEVATION 817.1
WDM-65-51
TOP ELEVATION 816.7
WDM-65-52
TOP ELEVATION 823.4
7 APRIL 1985
NO WATER LEVEL ENCOUNTERED
7 APRIL 1985
7 APRIL 1985
7 APRIL 1985
NO WATER LEVEL ENCOUNTERED
820
810
800
790
780
770
WDM-89-88
TOP ELEVATION 817.8
CH GR FAT CLAY
CL-CH BR SANDY MEDIUM CLAY
SC BR CLAYEY SAND
SP SC BR CLAYEY COARSE TO FINE SAND WITH GRAVEL
12 OCTOBER 1989
NO WATER LEVEL ENCOUNTERED
WDM-89-61
TOP ELEVATION 807.4
CL-CH BR SANDY MEDIUM CLAY
SP BR GRAVELLY COARSE TO FINE SAND
2 OCTOBER 1989
WDM-89-62
TOP ELEVATION 805.3
CL-CH GR MEDIUM CLAY
CH GR FAT CLAY
CL-CH BR MEDIUM CLAY
SP BR SAND (NO SAMPLE OBTAINED)
2 OCTOBER 1989
WDM-89-63
2 OCTOBER 1989
5
4
3
(A)



REFERENCE:

FOR LOCATION OF BORINGS
SEE PLATES 24, 26 & 27

Revisions			
Symbol	Descriptions	Date	Approved

U.S. ARMY ENGINEER DISTRICT
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ROCK ISLAND, ILLINOIS

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RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

BORING LOGS XI

Submitted
Approved
Drawing Control

Sheet reference number

Sheet ___ of ___

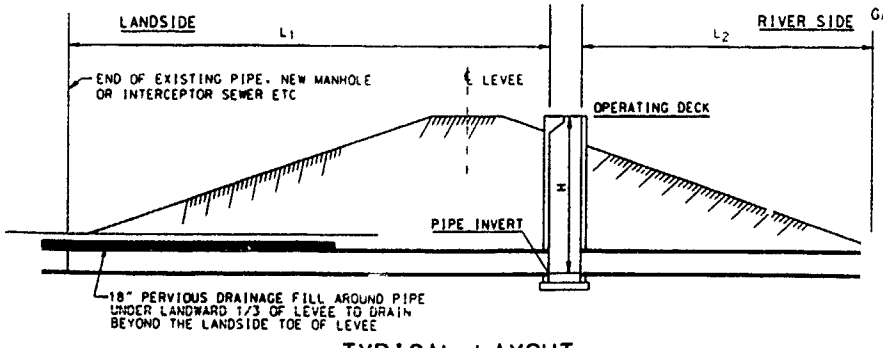
3 2 1

PLATE 34

(B)

SCHEDULE OF SEWERS, GATEWELLS, DRAINAGE STR

LOCATION ALONG C.B.L.	EXIST. PIPE		TYPE OF LIQUID	NEW PIPE		PIPE LENGTH		TYPE	IDENT. LETTER	TYPE	GATEWELL				SLUICE GATE	
	NOM. SIZE	TYPE		NOM. SIZE	TYPE	L_1	L_2				INSIDE DIM.	OPER. DECK EL.	H	PIPE INV. EL.	SIZE	TYPE
9+43	15"	R.C.P.	SANITARY	15"	R.C.P.	30'	15'	GATEWELL	A	PRECAST	4'-0"	48.5	17.7	30.8	15"	FLAT BA
13+50	18"	C.M.P.	STORM	48"	R.C.P.	32'	18'	GATEWELL	B	CAST IN PLACE	4'-0" X 5'-0"	47.9	11.4	36.5	48"	FLAT BA
43+60	TWIN 72"	R.C.P.	STORM	TWIN 72"	R.C.P.	29'	14'	GATEWELL	C	CAST IN PLACE	5'-0" X 16'-0"	46.8	12.8	34.0	TWIN 72"	FLAT BA
59+75	6' X6'	R.C.B.	STORM	6' X6'	R.C.B.	50'	35'	GATEWELL	D	CAST IN PLACE	5'-0" X 8'-0"	46.3	19.3	27.0	6' X 6'	FLAT BA
67+50	48"	R.C.P.	STORM	48"	R.C.P.	20'	55'	GATEWELL	E	CAST IN PLACE	4'-0" X 5'-6"	46.0	19.5	26.5	48"	FLAT BA
81+50			STORM	5' X7'	R.C.B.	53'	23'	GATEWELL	F	CAST IN PLACE	*	50.5	24.8	25.7	5' X 7'	FLAT BA
100+45			STORM	24"	R.C.P.	36'	36'	GATEWELL	G	PRECAST	4'-0"	44.4	13.4	31.0	24"	FLAT BA
103+50	36"	R.C.P.	STORM	36"	R.C.P.	32'	15'	GATEWELL	H	CAST IN PLACE	4'-0" X 4'-6"	44.2	18.8	25.4	36"	FLAT BA
104+20	42"	R.C.P.	SANITARY	42"	R.C.P.	40'	21'	GATEWELL	I	CAST IN PLACE	4'-0" X 5'-6"	44.2	24.7	19.5	42"	FLAT BA
116+20	36"	R.C.P.	SANITARY	42"	R.C.P.	54'	44'	GATEWELL	J	CAST IN PLACE	4'-0" X 5'-6"	42.2	24.7	17.5	42"	FLAT BA
127+80	18"	C.M.P.														
135+30	18"	C.M.P.														
142+60	24"	R.C.P.	SANITARY	24"	R.C.P.	42'	22'	GATEWELL	K	CAST IN PLACE	4'-0" X 4'-0"	42.2	22.2	20.0	24"	FLAT BA
142+80	48"	R.C.P.	SANITARY	48"	R.C.P.	42'	22'	GATEWELL	L	CAST IN PLACE	4'-0" X 5'-6"	42.2	24.2	18.0	48"	FLAT BA
147+00	30"	C.M.P.	STORM	48"	R.C.P.	45'	31'	GATEWELL	M	CAST IN PLACE	4'-0" X 5'-6"	42.2	15.2	26.5	48"	FLAT BA
170+67	30"	R.C.P.														
170+85	24"	R.C.P.														
179+05	30"	C.M.P.														
183+65	24"	R.C.P.														
184+00	15"	R.C.P.	SANITARY	15"	R.C.P.	5'	5'	GATEWELL	N	PRECAST	4'-0"	44.0	12.0	32.0	15"	FLAT BA
184+90	36"	R.C.P.														
186+00	15"	R.C.P.	STORM	15"	R.C.P.	77'										
186+60	36"	R.C.P.														
187+85	36"	R.C.P.	STORM	5'X7'	R.C.B.	125'	30'	GATEWELL	O	CAST IN PLACE	*	56.5	26.5	30.5	5' X 7'	FLAT BA
191+45	36"	R.C.P.														
191+50	36"	R.C.P.	SANITARY	36"	R.C.P.	5'	5'	GATEWELL	P	CAST IN PLACE	4'-0" X 4'-6"	52.4	14.4	38.0	36"	FLAT BA
202+70	24"	C.M.P.	STORM	24"	R.C.P.	65'	30'	GATEWELL	Q	PRECAST	4'-0"	52.9	13.9	39.0	24"	FLAT BA
214+45	30"	C.M.P.														
215+80	36"	R.C.P.	SANITARY	36"	R.C.P.	42'	76'	GATEWELL	R	CAST IN PLACE	4'-0" X 4'-6"	54.5	20.3	34.2	36"	FLAT BA
PONDING "A"	36"	R.C.P.	STORM	48"	R.C.P.	80'	30'	GATEWELL	S	CAST IN PLACE	4'-0" X 5'-6"	49.0	12.0	37.0	48"	FLAT BA



TYPICAL LAYOUT

NO SCALE

GATEWELL NOTES:

1. EXISTING INVERT ELEVATIONS ARE TO BE VERIFIED. THE INVERTS MAY BE ADJUSTED BY THE CONTRACTING OFFICER.
2. ALL SLIDE GATES SHALL BE CAST IRON, FLUSH BOTTOM WITH SIDE WEDGES & BRONZE LIFTING NUTS.
3. ALL WALL THIMBLES SHALL BE "F" TYPE. GATEWELL THIMBLES SHALL HAVE ROUND OPENINGS AND SQUARE FLANGES, EXCEPT AS OTHERWISE NOTED.
4. ENCLOSED GEAR PEDESTAL LIFTS SHALL BE SINGLE SPEED CRANK TYPE HAVING A 25 POUND MAXIMUM CRANK PULL.
5. PEDESTAL LIFTS SHALL HAVE GATE POSITION INDICATORS AND STEEL GALVANIZED STEM COVERS.
6. LOCATE PEDESTAL LIFTS AND ACCESSORIES FROM DIMENSIOI FURNISHED BY THE GATE MANUFACTURER.
7. ALL ANCHOR BOLTS FOR GATES AND ACCESSORIES SHALL BE SUPPLIED BY THE GATE MANUFACTURER.
8. PLACE ½" PERFORMED EXPANSION JOINT FILLER AT ALL POINTS OF CONTACT BETWEEN GATEWELL AND CONCRETE PIPI
9. ELECTRICALLY OPERATED TRIPOD MOUNTED PORTABLE OPERATORS WITH REVERSING FEATURES AND AN OVERLOAD RELEASE CLUTCH SHALL BE PROVIDE FOR RAISING AND LOWERING THE GATES.
10. A CHAIN AND PADLOCK SHALL BE PROVIDED AT EACH GATEWELL FOR LOCKING THE REMOVABLE CRANK TO THE HOISTING PEDESTAL.

(A)

WELLS. DRAINAGE STRUCTURES. AND APPURTENANCES

	GATEWELL				SLUICE GATE		GATE HEAD REQUIRMENTS			STEM MATERIAL	REF. PLATES	REMARKS
	INSIDE DIM.	OPER. DECK EL.	H	PIPE INV. EL.	SIZE	TYPE	SEATING HEAD	UNSEATING HEAD	OPERATING HEAD			
	4'-0"	48.5	17.7	30.8	15"	FLAT BACK	17.0	10'	17.0	STAINLESS	4	REMOVE 50' OF 15" R.C.P.
ACE	4'-0" X 5'-0"	47.9	11.4	36.5	48"	FLAT BACK	9.4	10'	9.4	COLD ROLLED	5	REMOVE 50' OF 18" C.M.P.
ACE	5'-0" X 16'-0"	46.8	12.8	34.0	TWIN 72"	FLAT BACK	9.8	10'	9.8	COLD ROLLED	7	REMOVE EXISTING CONCRETE HEADWALLS
ACE	5'-0" X 8'-0"	46.3	19.3	27.0	6' X 6'	FLAT BACK	17.3	10'	17.3	COLD ROLLED	8	REMOVE EXISTING FLAPGATE
ACE	4'-0" X 5'-6"	46.0	19.5	26.5	48"	FLAT BACK	18.0	10'	18.0	COLD ROLLED	9	REMOVE 25' OF 48" R.C.P. AND CONSTRUCT NEW JUNCTION BOX ON 48" R.C.P.
ACE	*	50.5	24.8	25.7	5' X 7'	FLAT BACK	17.3	10'	17.3	COLD ROLLED	10	* PUMPING STATION. SEE PLATE 47
	4'-0"	44.4	13.4	31.0	24"	FLAT BACK	12.4	10'	12.4	COLD ROLLED	12	
ACE	4'-0" X 4'-6"	44.2	18.8	25.4	36"	FLAT BACK	17.3	10'	17.3	COLD ROLLED	12	REMOVE 50' OF 36" R.C.P.
ACE	4'-0" X 5'-6"	44.2	24.7	19.5	42"	FLAT BACK	23.0	10'	23.0	STAINLESS	12	REMOVE 65' OF 42" R.C.P.
ACE	4'-0" X 5'-6"	42.2	24.7	17.5	42"	FLAT BACK	17.7	10'	17.7	STAINLESS	13	REMOVE 98' OF 36"R.C.P. & 155' OF 18"R.C.P
											14	REMOVE 82' OF 18" C.M.P.
											15	REMOVE 60' OF 18" C.M.P.
ACE	4'-0" X 4'-0"	42.2	22.2	20.0	24"	FLAT BACK	21.2	10'	21.2	STAINLESS	15	ASSUMED INVERT-REMOVE 68' OF 24" R.C.P.
ACE	4'-0" X 5'-6"	42.2	24.2	18.0	48"	FLAT BACK	22.5	10'	22.5	STAINLESS	15	REMOVE 68' OF 48" R.C.P.
ACE	4'-0" X 5'-6"	42.2	15.2	26.5	48"	FLAT BACK	13.7	10'	13.7	COLD ROLLED	16	REMOVE 100' OF 30" C.M.P.
											18	REMOVE 70' OF 30" R.C.P.
											18	REMOVE 70' OF 24" R.C.P.
											18	REMOVE 10' OF 30" C.M.P. PLUG & ABANDON
	4'-0"	44.0	12.0	32.0	15"	FLAT BACK	11.4	10'	11.4	STAINLESS	19	REMOVE 10' OF 24" R.C.P. PLUG & ABANDON
											19	REMOVE 10' OF 15" R.C.P.
											19	REMOVE 10' OF 36" R.C.P. PLUG & ABANDON
											19	REMOVE 60' OF 15" R.C.P. PLUG & ABANDON
ACE	*	56.5	26.5	30.5	5' X 7'	FLAT BACK	18.9	10'	18.9	COLD ROLLED	19	REMOVE 10' OF 36" R.C.P. PLUG & ABANDON
ACE	4'-0" X 4'-6"	52.4	14.4	38.0	36"	FLAT BACK	12.6	10'	12.6	STAINLESS	19	* PUMPING STATION. SEE PLATE 49
											19	REMOVE 10' OF 36" R.C.P. PLUG & ABANDON
	4'-0"	52.9	13.9	39.0	24"	FLAT BACK	12.9	10'	12.9	COLD ROLLED	19	REMOVE 10' OF 36" R.C.P.
ACE	4'-0" X 4'-6"	54.5	20.3	34.2	36"	FLAT BACK	18.8	10'	18.8	STAINLESS	20	REMOVE 45' OF 24" C.M.P.
											21	REMOVE 38' OF 30" C.M.P.
ACE	4'-0" X 5'-6"	49.0	12.0	37.0	48"	FLAT BACK	8.0	8'	8.0	COLD ROLLED	21	REMOVE 118' OF 36" R.C.P.
											24	REMOVE 110' OF 36" R.C.P.

GATEWELL NOTES:

1. EXISTING INVERT ELEVATIONS ARE TO BE VERIFIED. THE INVERTS MAY BE ADJUSTED BY THE CONTRACTING OFFICER.
2. ALL SLIDE GATES SHALL BE CAST IRON. FLUSH BOTTOM WITH SIDE WEDGES & BRONZE LIFTING NUTS.
3. ALL WALL THIMBLES SHALL BE "F" TYPE. GATEWELL THIMBLES SHALL HAVE ROUND OPENINGS AND SQUARE FLANGES. EXCEPT AS OTHERWISE NOTED.
4. ENCLOSED GEAR PEDESTAL LIFTS SHALL BE SINGLE SPEED CRANK TYPE HAVING A 25 POUND MAXIMUM CRANK PULL.
5. PEDESTAL LIFTS SHALL HAVE GATE POSITION INDICATORS AND STEEL GALVANIZED STEM COVERS.
6. LOCATE PEDESTAL LIFTS AND ACCESSORIES FROM DIMENSIONS FURNISHED BY THE GATE MANUFACTURER.
7. ALL ANCHOR BOLTS FOR GATES AND ACCESSORIES SHALL BE SUPPLIED BY THE GATE MANUFACTURER.
8. PLACE ½" PERFORMED EXPANSION JOINT FILLER AT ALL POINTS OF CONTACT BETWEEN GATEWELL AND CONCRETE PIPE.
9. ELECTRICALLY OPERATED TRIPOD MOUNTED PORTABLE OPERATORS WITH REVERSING FEATURES AND AN OVERLOAD RELEASE CLUTCH SHALL BE PROVIDE FOR RAISING AND LOWERING THE GATES.
10. A CHAIN AND PADLOCK SHALL BE PROVIDED AT EACH GATEWELL FOR LOCKING THE REMOVABLE CRANK TO THE HOISTING PEDESTAL.

CONCRETE & REINFORCING NOTES FOR GATEWELLS AND HEADWALLS:

1. CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 3,000psi.
2. ALL REINFORCING SHALL BE A.S.T.M. 615-89 GRADE 60(fy=60,000psi). ALL REINFORCING DETAILING SHALL BE IN ACCORDANCE WITH ACI CODE 318-89.
3. CLEAR DISTANCE FOR REINFORCING IS 2" FOR WALLS. 2½" FOR TOPS OF SLABS. AND 3" FOR BOTTOM SLABS CAST AGAINST EARTH UNLESS SHOWN OTHERWISE ON DRAWINGS
4. ALL EXPOSED CORNERS 90° OR SHARPER ARE TO BE FILLETED WITH A DRESSED BEVELED STRIP. SIDES OF FOOTINGS ARE TO BE FORMED TO INSURE LINE AND GRADE.

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

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Reviewed by
Approved by: JOHN R. BROWN, CHIEF, CORPS OF ENGINEERS

US Army Corps of Engineers

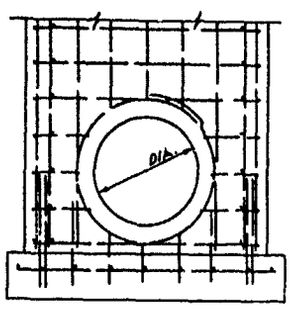
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

SEWER AND GATEWELL SCHEDULE

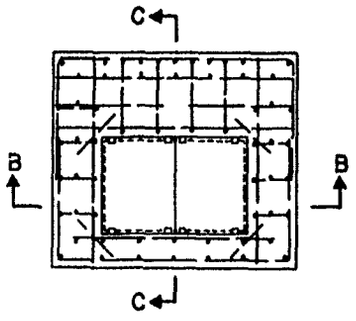
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PLATE 35

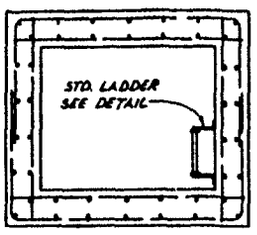
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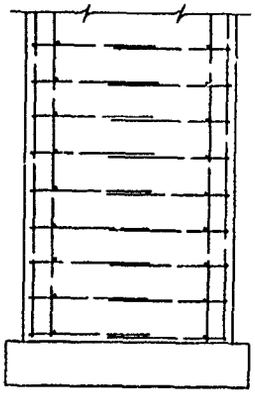
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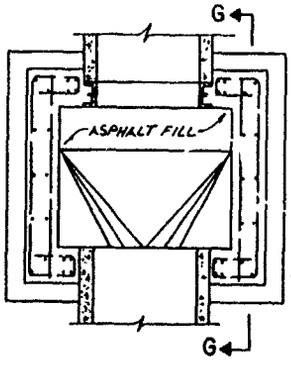
PLAN-TOP OF SLAB



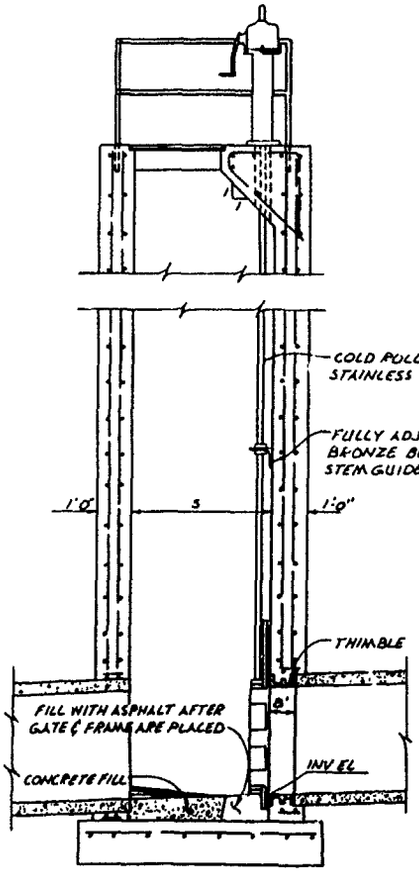
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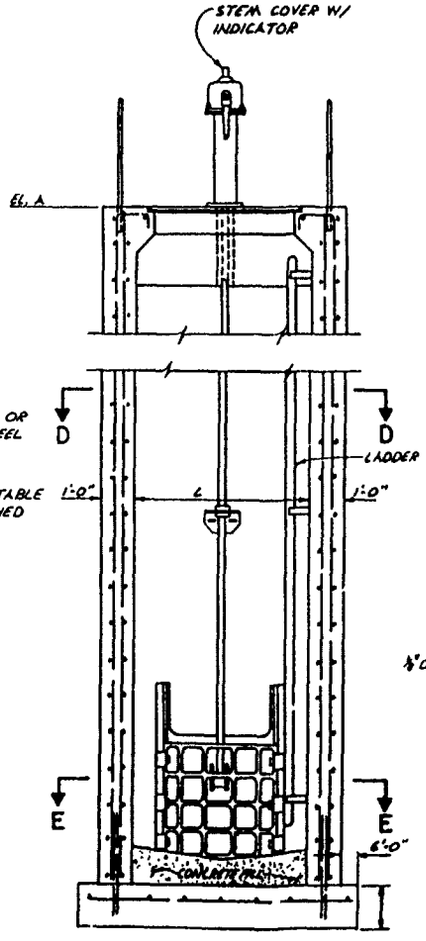
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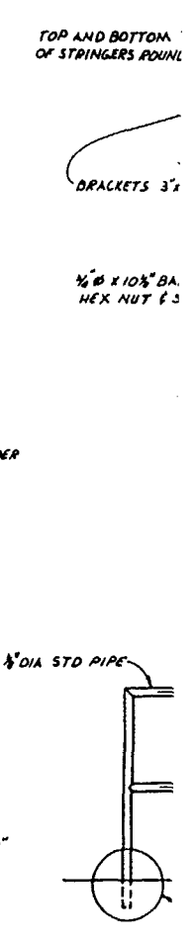
SECTION E-E



SECTION C-C



SECTION B-B



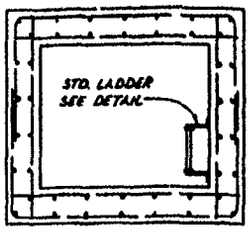
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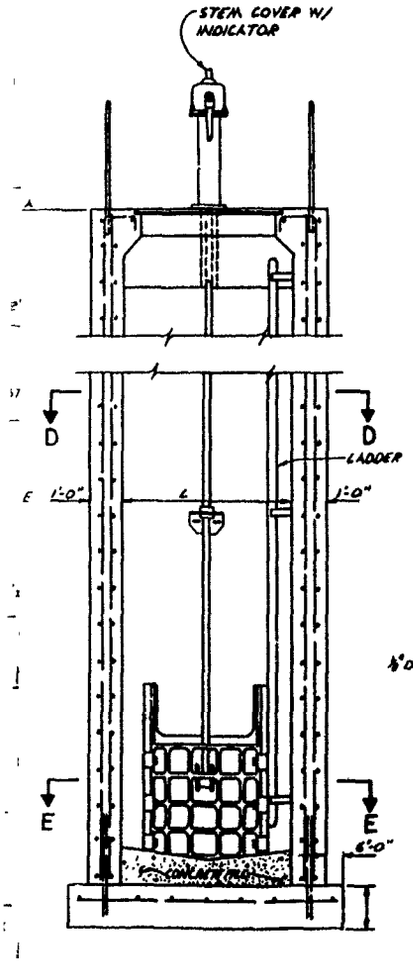
INDEX OF CAST IN PLACE GATEWELLS

IDENT.	LOCATION	PIPE		DIMENSIONS				REMARKS
		TYPE	DIA.	S	L	EL. A	INV. EL.	
B	13+80	R.C.P.	48"	4'-0"	8'-0"	47.9	36.8	
C	43+80	R.C.P.	72"	5'-0"	16'-0"	46.8	34.0	
D	59+75	R.C.B.	6'X8'	5'-0"	8'-0"	46.3	28.0	
E	67+80	R.C.P.	48"	4'-0"	8'-8"	46.0	28.0	
H	103+50	R.C.P.	36"	4'-0"	4'-8"	44.2	28.4	
I	104+20	R.C.P.	42"	4'-0"	8'-8"	44.2	19.5	*
J	118+20	R.C.P.	42"	4'-0"	8'-8"	42.2	17.5	*
K	142+60	R.C.P.	24"	4'-0"	4'-0"	42.2	20.0	*
L	142+80	R.C.P.	48"	4'-0"	8'-8"	42.2	18.0	*
M	147+00	R.C.P.	48"	4'-0"	8'-8"	42.2	26.5	
P	191+50	R.C.P.	36"	4'-0"	4'-8"	52.4	38.0	
R	215+80	R.C.P.	36"	4'-0"	4'-8"	54.5	34.2	
S	POND "A"	R.C.P.	48"	4'-0"	8'-8"	49.0	37.0	

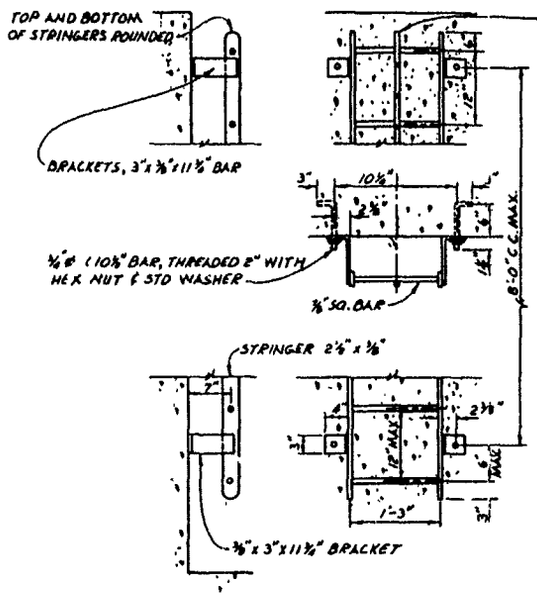
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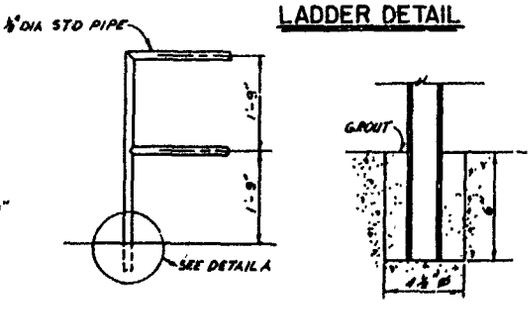
SECTION D-D



SECTION B-B



LADDER DETAIL



STD. HANDRAIL DETAILS

Revisions			
Symbol	Descriptions	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

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Reviewed by
Approved by

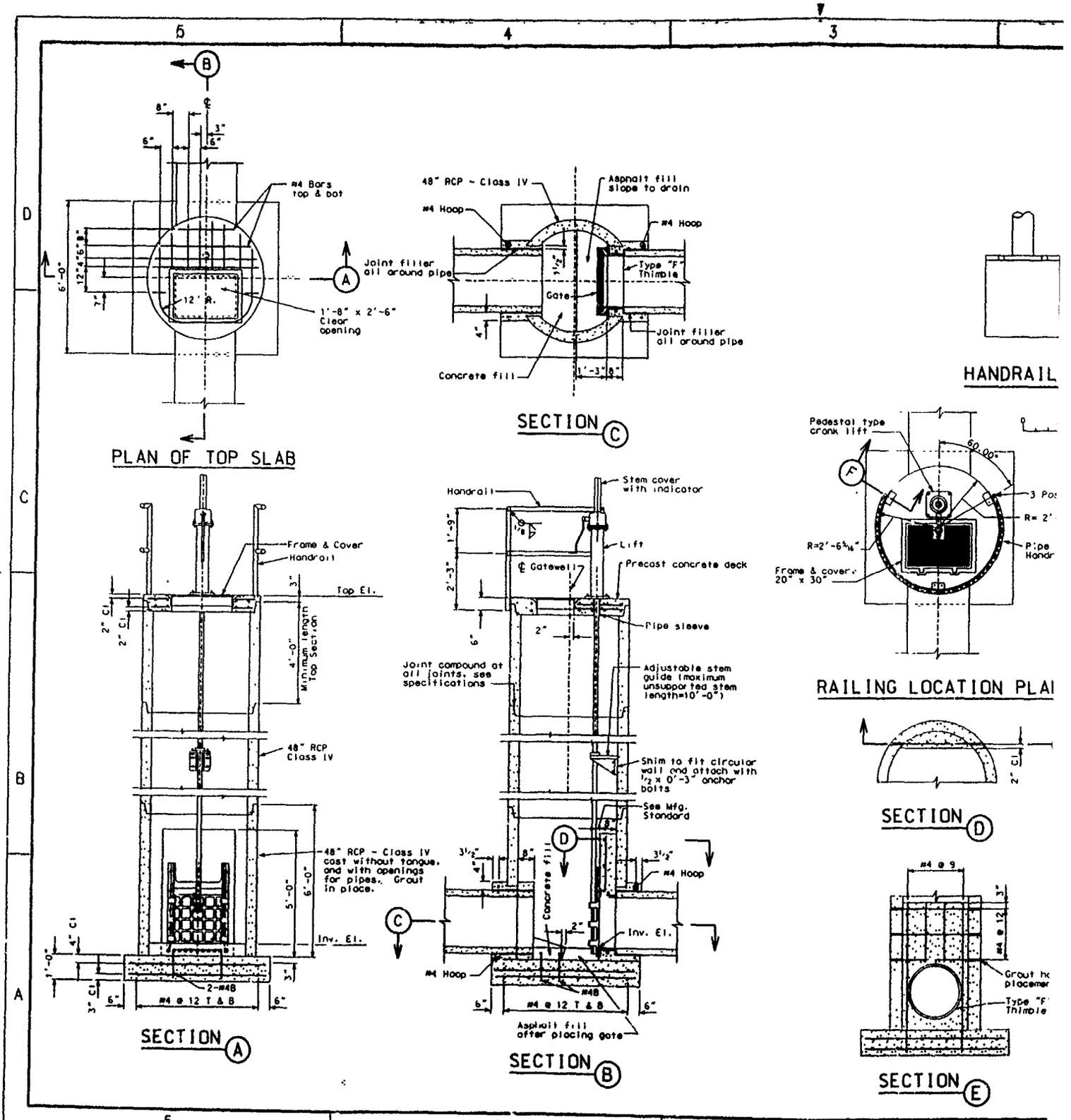
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

CAST - IN - PLACE
GATEWELL DETAILS

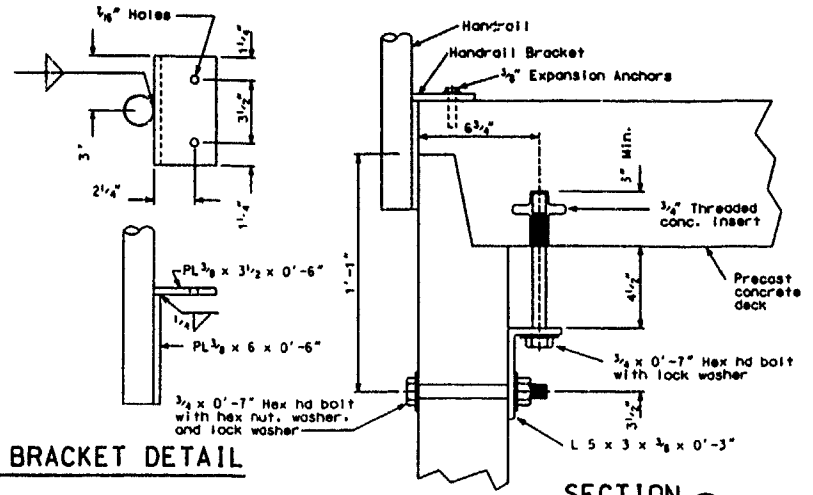
Scale
Date
Drawing Code
Sheet reference numbers
Sheet _ of _

PLATE 36

(B)


#4 Bars top & bot
12" R.
1'-8" x 2'-6" Clear opening
Joint filler all around pipe
PLAN OF TOP SLAB
48" RCP - Class IV
Asphalt fill slope to drain
#4 Hoop
Type "F" Thimble
Gate
Joint filler all around pipe
Concrete fill
SECTION C
HANDRAIL
Frame & Cover
Handrail
Top El.
Minimum length Top Section
48" RCP Class IV
48" RCP - Class IV cast without tongue, and with openings for pipes. Grout in place.
Inv. El.
2-#4B
#4 @ 12 T & B
SECTION A
Handrail
Stem cover with indicator
Lift
℄ Gatewell
Precast concrete deck
Pipe sleeve
Joint compound at all joints, see specifications
Adjustable stem guide (maximum unsupported stem length=10'-0")
Shim to fit circular wall and attach with 1/2 x 0'-3" anchor bolts
See Mfg. Standard
Concrete fill
#4 Hoop
Inv. El.
#4B
Asphalt fill after placing gate
SECTION B
Pedestal type crank lift
60.00°
3 Pos
R= 2'
R=2'-6 5/16"
Pipe Handr
Frame & cover 20" x 30"
RAILING LOCATION PLAN
SECTION D
#4 @ 9
#4 @ 12
Grout ho placemer
Type "F" Thimble
SECTION E

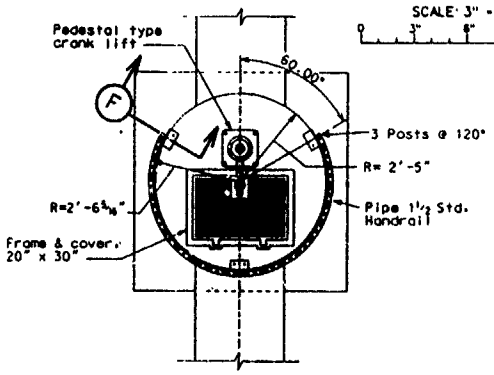
(A)



HANDRAIL BRACKET DETAIL

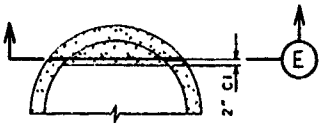
SECTION (F)

SCALE 3" = 1'-0"

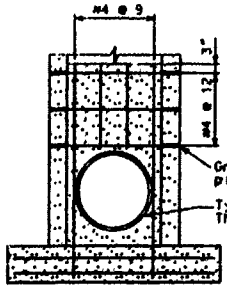


SCALE: 3" = 1'-0"

RAILING LOCATION PLAN

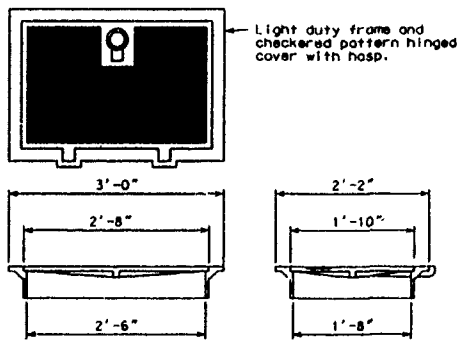


SECTION (D)



SECTION (E)

SCALE: 1/2" = 1'-0"



MANHOLE FRAME AND COVER

SCALE: 1" = 1'-0"

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

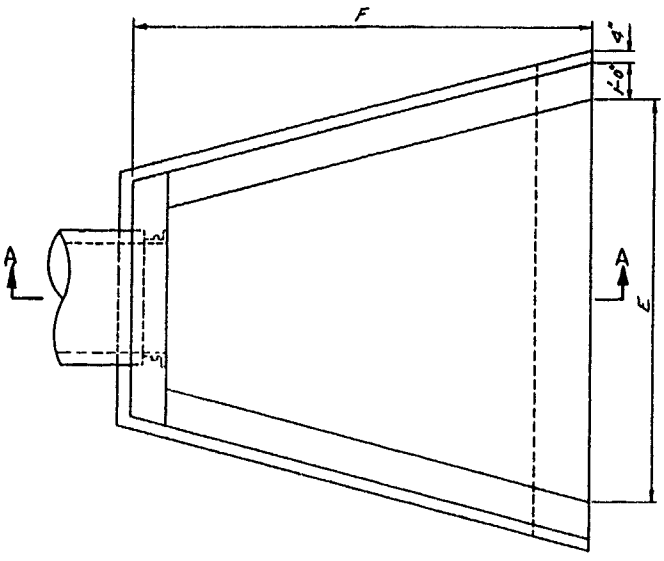
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

STANDARD PRECAST GATEWELL DETAILS

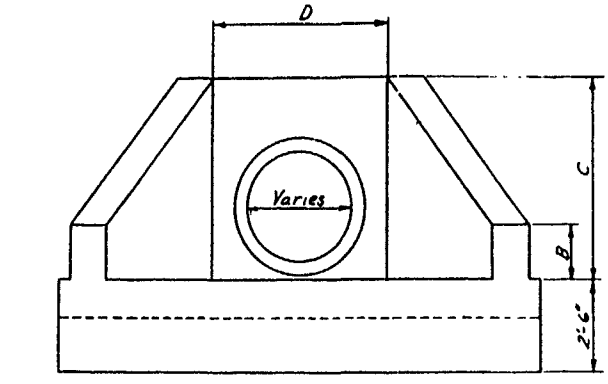
Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:
Scale 1/2" = 1'-0"
Date:
Drawing Control:
Sheet reference number:
Solicitation Number: DACW25- -B-
Sheet of

PLATE 37

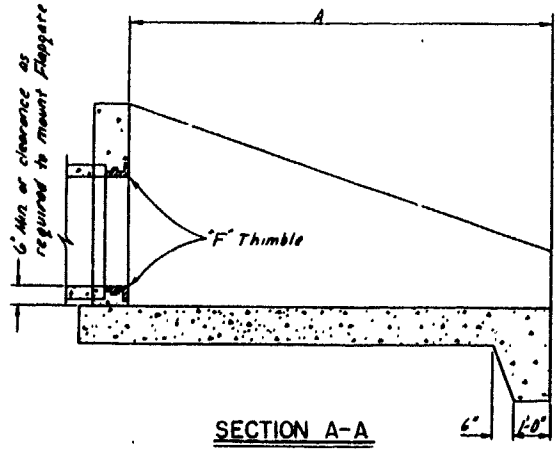
(B)



PLAN



END ELEVATION

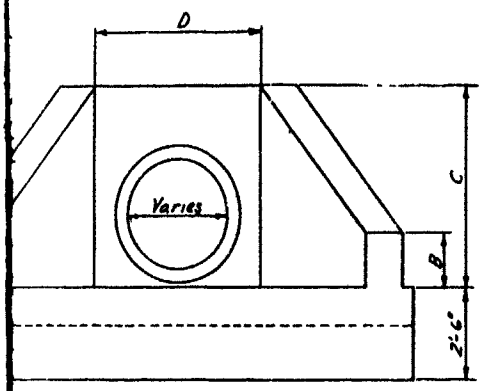


SECTION A-A

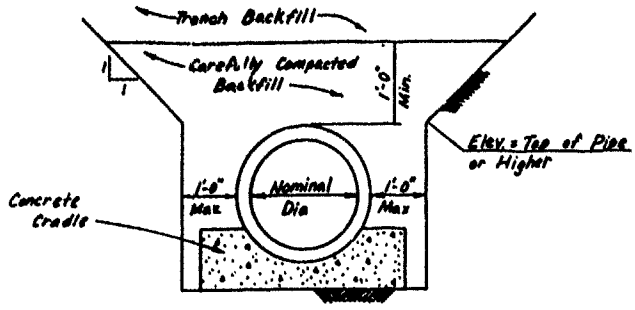
HEADWALL DETAILS

HEADWALL DIMENSION

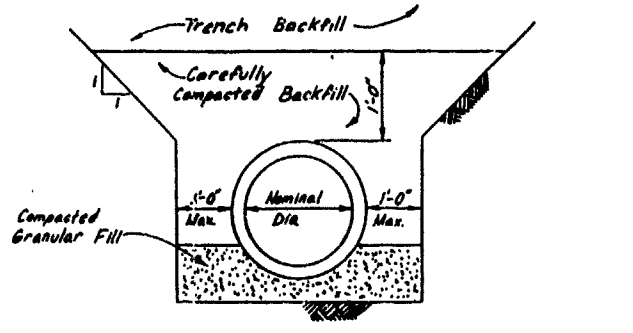
ITEM	PIPE DIA	A	B	C	D	
GATEWELL B	48"	11'-3"	3'-0"	7'-6"	6'-6"	12
C	TWIN 72"	19'-0"	3'-0"	8'-6"	19'-0"	2
D	6'X 6'	19'-0"	3'-0"	8'-6"	6'-0"	1
E	48"	11'-3"	3'-0"	7'-6"	6'-6"	12
F	6'-0"X7'-0"	16'-0"	3'-0"	7'-6"	10'-0"	1
H	36"	10'-0"	1'-6"	6'-6"	6'-0"	1
M	48"	11'-3"	3'-0"	7'-6"	6'-6"	12
O	6'-X7'-0"	16'-0"	3'-0"	7'-6"	10'-0"	1



END ELEVATION



CLASS A BEDDING DETAILS



CLASS C BEDDING DETAILS

HEADWALL DIMENSION

EM	PIPE DIA.	A	B	C	D	E	F
B	48"	11'-3"	5'-0"	7'-6"	6'-6"	12'-11 1/2"	12'-6"
C	TWIN 72"	19'-0"	5'-6"	8'-6"	18'-0"	22'-0"	20'-0"
D	6'X 6'	19'-0"	5'-0"	8'-6"	6'-6"	18'-0"	20'-0"
E	48"	11'-3"	5'-0"	7'-6"	6'-6"	12'-11 1/2"	12'-6"
F	5'-0"X7'-6"	19'-0"	5'-0"	7'-6"	18'-0"	18'-0"	17'-6"
M	36"	10'-0"	1'-6"	5'-6"	6'-6"	10'-0"	11'-6"
M	48"	11'-3"	5'-6"	7'-6"	6'-6"	12'-11 1/2"	12'-6"
O	5'-X7'-6"	19'-0"	5'-6"	7'-6"	18'-0"	18'-0"	17'-6"

LS

Symbol	Revisions Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

HEADWALL AND BEDDING DETAIL

Designed by
Drawn by
Checked by
Recommended by
Approved by

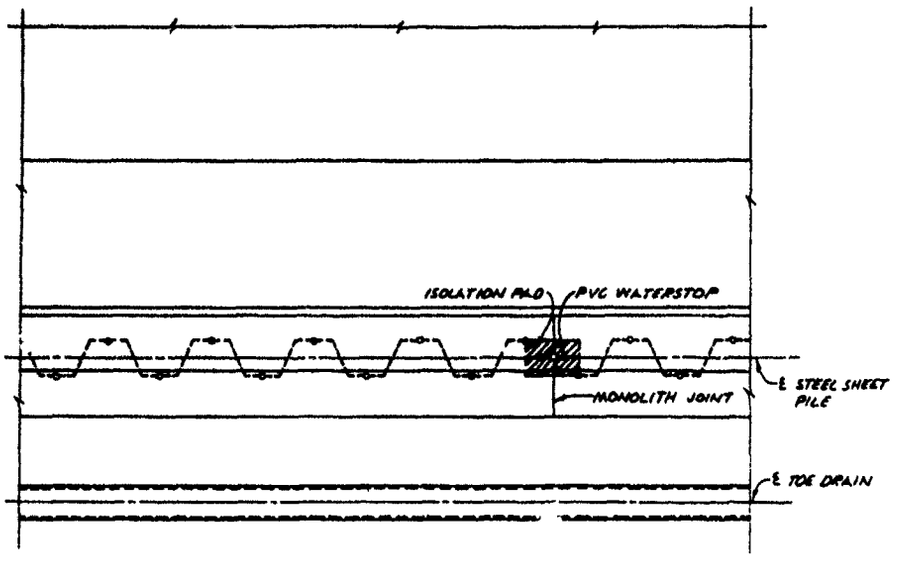
Drawn
Traced
Recorded by

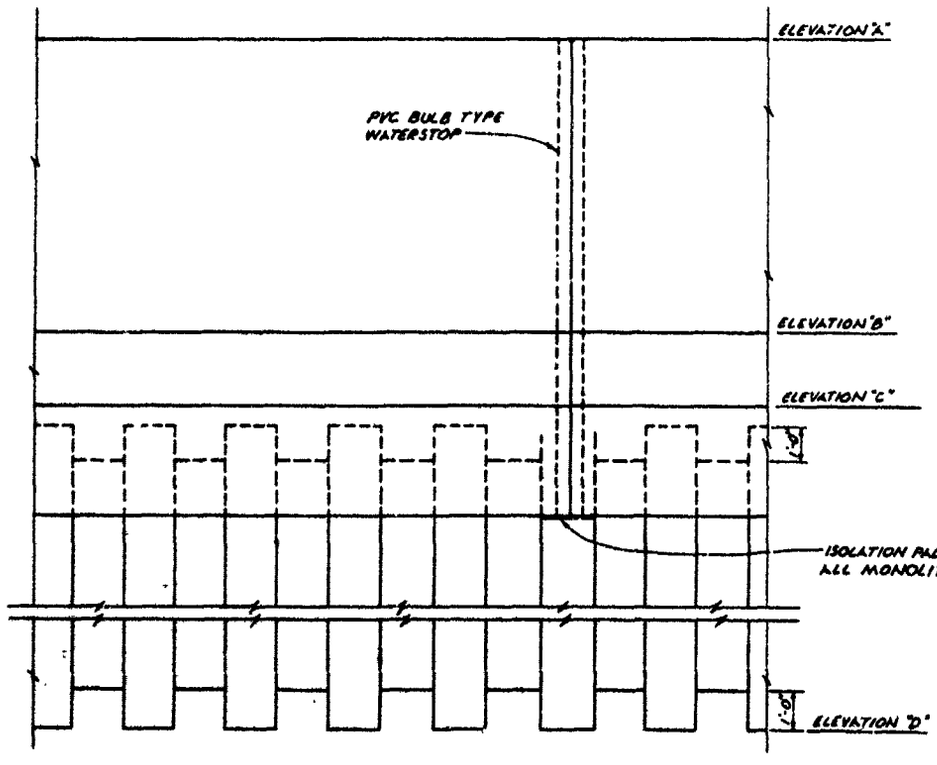
Sheet reference numbers

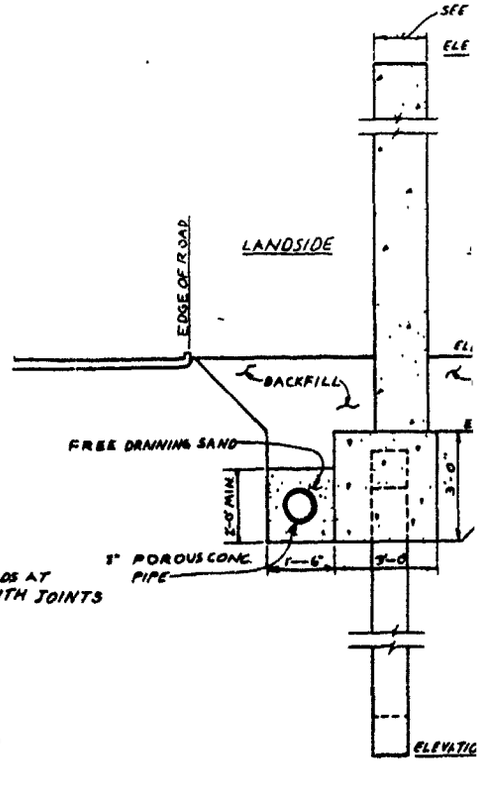
Sheet __ of __

PLATE 38

B


ISOLATION PAD
PVC WATERSTOP
℄ STEEL SHEET PILE
MONOLITH JOINT
℄ TOE DRAIN


ELEVATION "A"
PVC BULB TYPE WATERSTOP
ELEVATION "B"
ELEVATION "C"
ISOLATION PADS AT ALL MONOLITH JOINTS
1'-0"
ELEVATION "D"

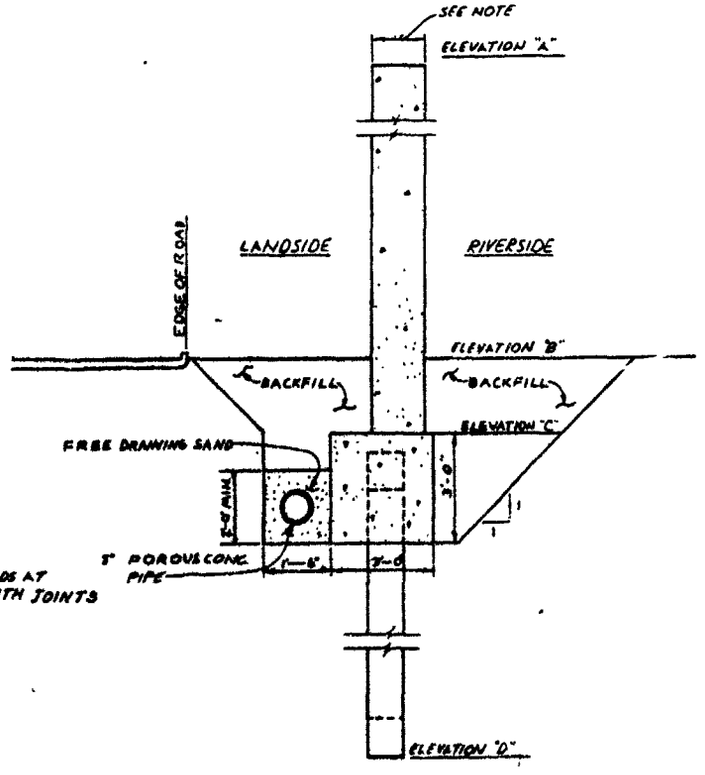

SEE
ELE
LANDSIDE
EDGE OF ROAD
BACKFILL
FREE DRAINING SAND
2'-0" MIN.
3" POROUS CONC. PIPE
1'-6"
3'-0"
3'-0"
ELEVATIO

(A)

I-WALL DATA							
STATION		ELEVATION				TOE DRAIN	REFERENCE PLATES
FROM	TO	A	B	C	D		
177+68	180+00	49.0	45.0	43.5	31.5	REQUIRED	18
180+00	184+80	50.0	44.0	42.5	24.5	•	19
184+80	189+46	51.3	44.3	42.8	28.3	•	19
189+86	192+80	52.3	44.5	42.8	20.3	•	19,20
192+80	195+17	52.6	42.6	41.1	12.6	•	20
217+40	217+78	54.5	47.2	45.7	23.5	•	22
218+22	219+37	54.5	47.2	45.7	23.5	•	22

℄ STEEL SHEET PILE

℄ TOE DRAIN



Notes

1. Monolith joints shall be spaced 30'-0" apart

No.	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
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ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:

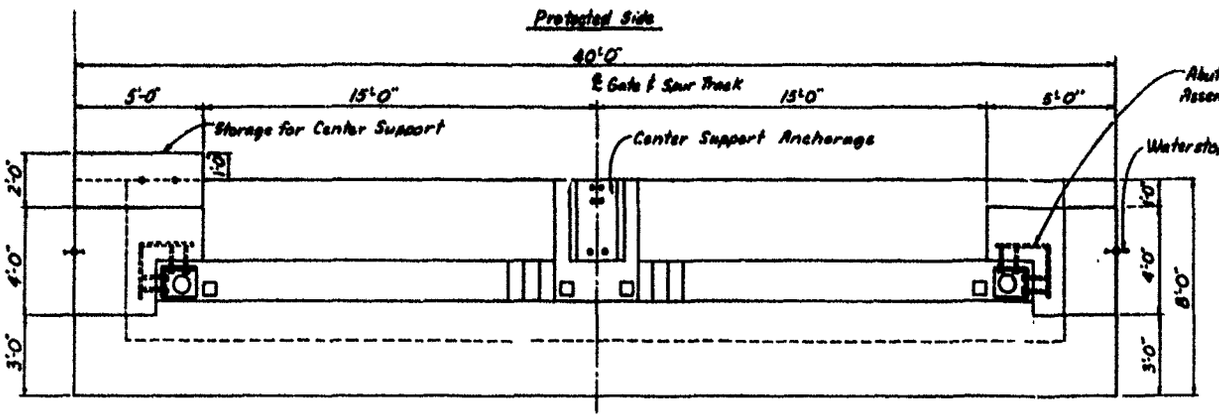
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

TYPICAL I-WALL DETAILS

Contract
Status
Sheet reference numbers
Sheet ... of ...

PLATE 38

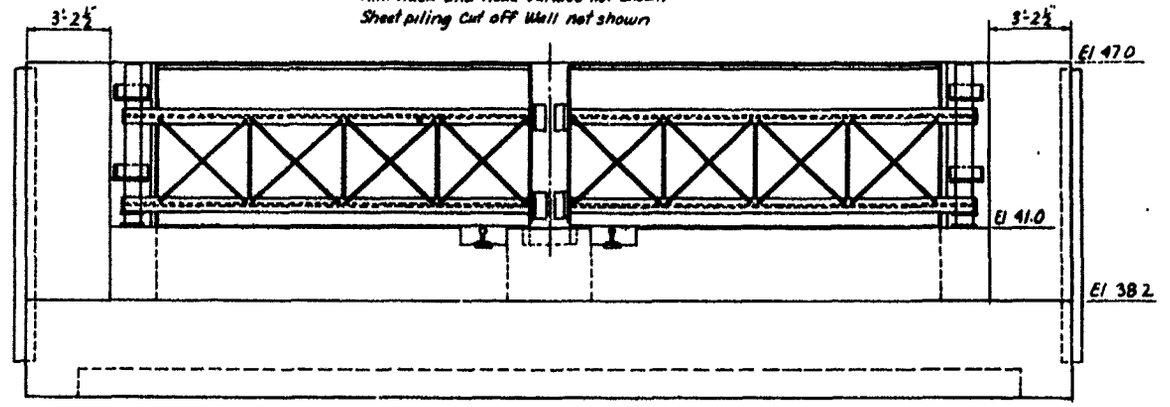
(B)



Flood Side

PLAN

Gate not shown, Center Support not in place.
R.R. Track and Road Surface not shown
Sheet piling Cut off Wall not shown



ELEVATION

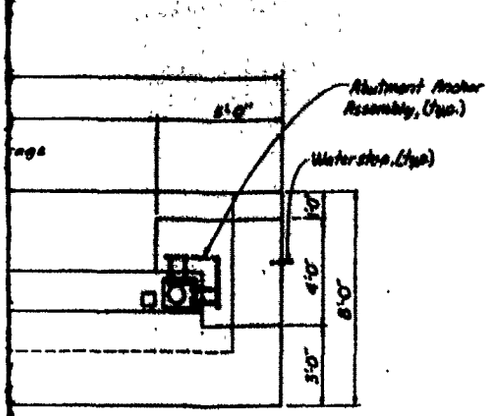
Gate Closed, Center Support in place
Sheet piling cut off Wall not shown

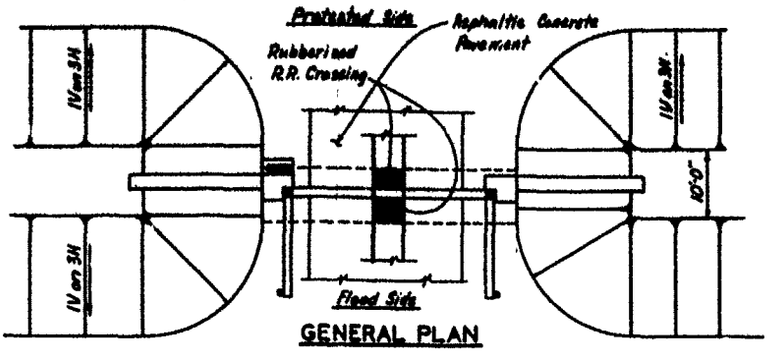
Flood Side

El 38.

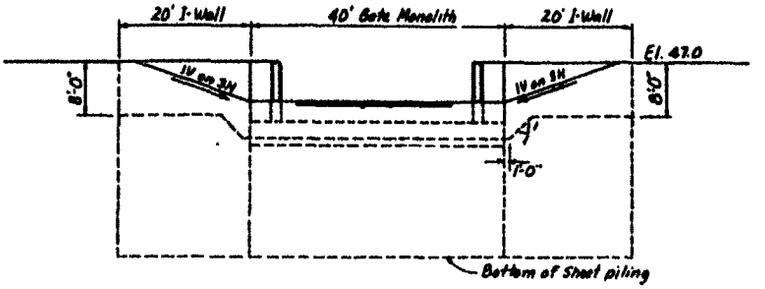
El. 34.7

(A)

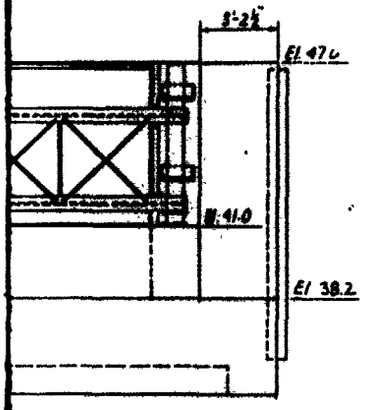


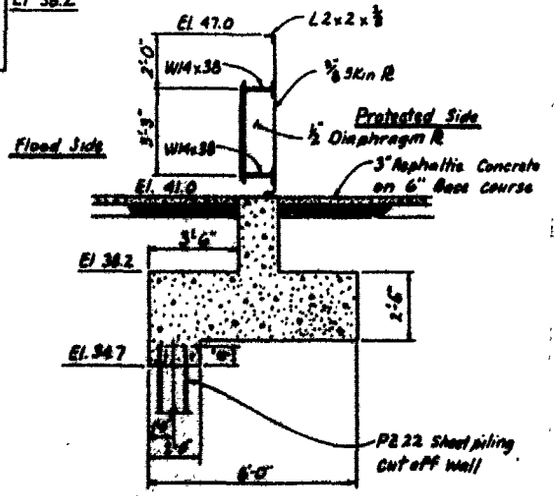


GENERAL PLAN



GENERAL ELEVATION





TYPICAL SECTION

Gate Closed, Center Support not shown

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

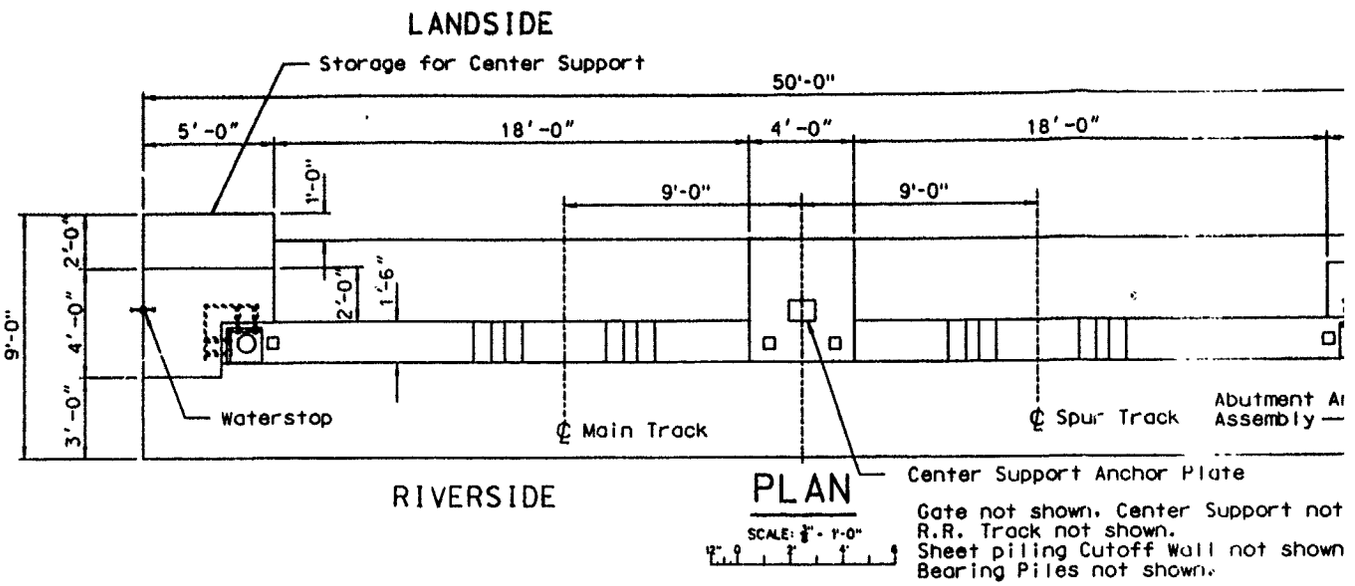
MISSOURI RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION
MARTIN MARIETTA

Designed by
Drawn by
Checked by
Reviewed by
Approved by

Scale: 3/8" = 1'-0"
Date:
Sheet ... of ... Sheets

PLATE 48

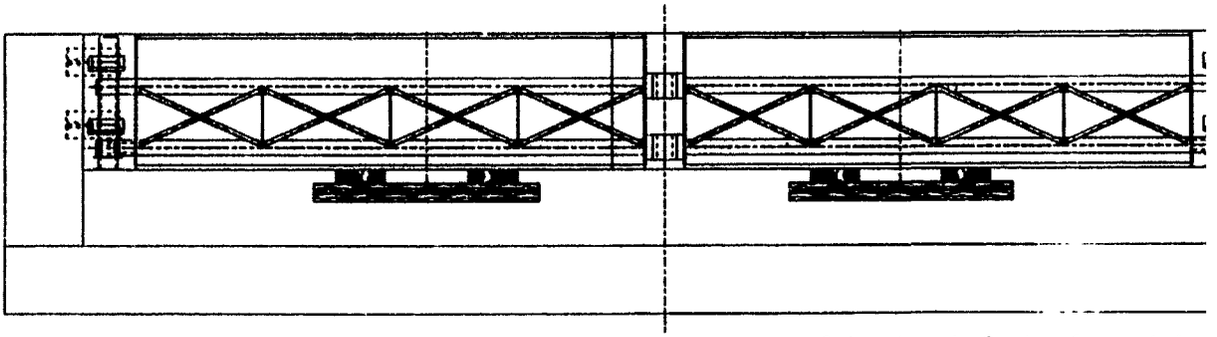
(B)



PLAN

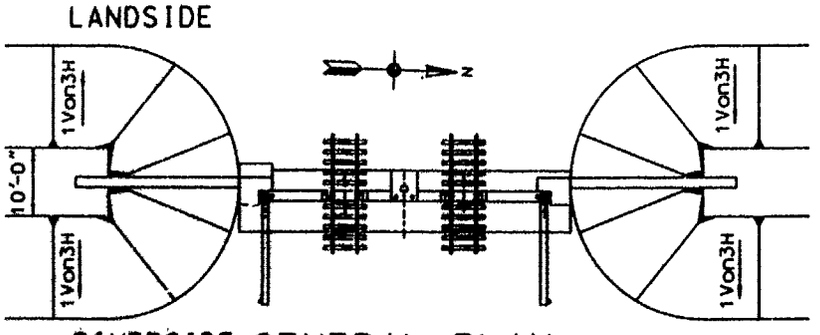
SCALE: 1/8" - 1'-0"

Gate not shown. Center Support not
R.R. Track not shown.
Sheet piling Cutoff Wall not shown
Bearing Piles not shown.



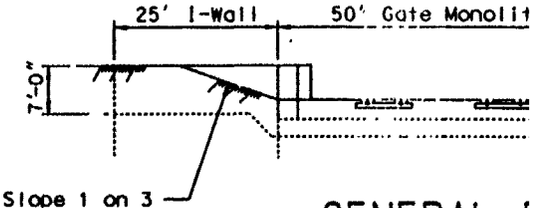
ELEVATION

Gate closed. Center Support in
Sheet piling Cutoff Wall not sh
Bearing Piles not shown.

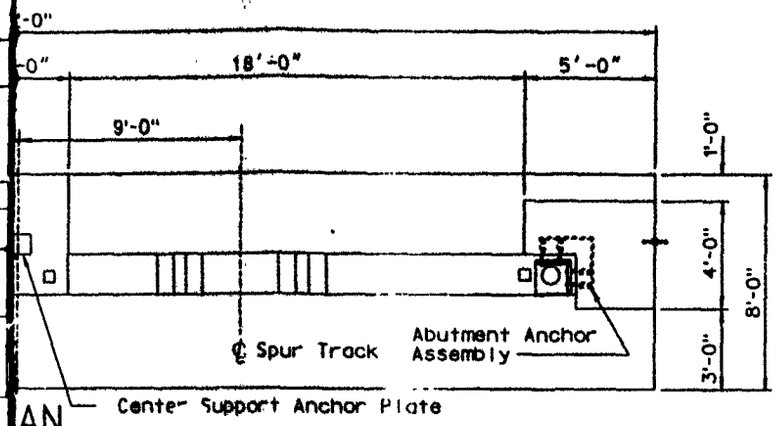


RIVERSIDE GENERAL PLAN

SCALE: 1/8" - 1'-0"

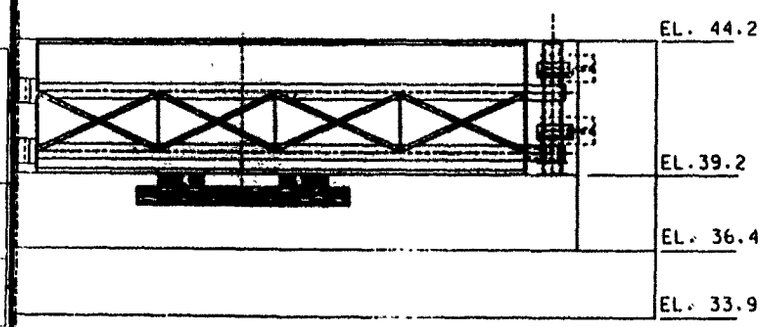


GENERAL



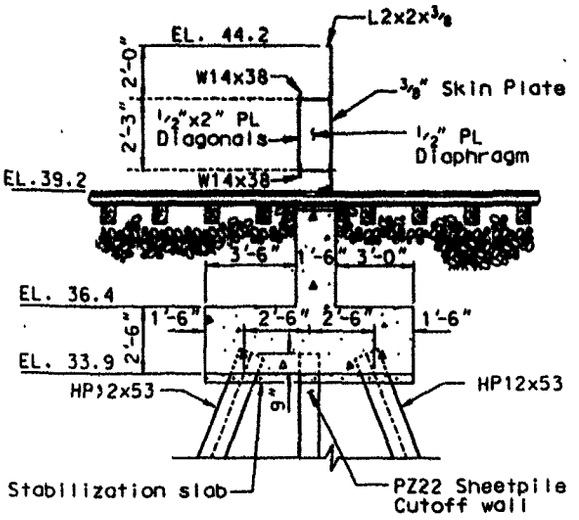
AN

Gate not shown. Center Support not in place.
R.R. Track not shown.
Sheet piling Cutoff Wall not shown.
Bearing Piles not shown.

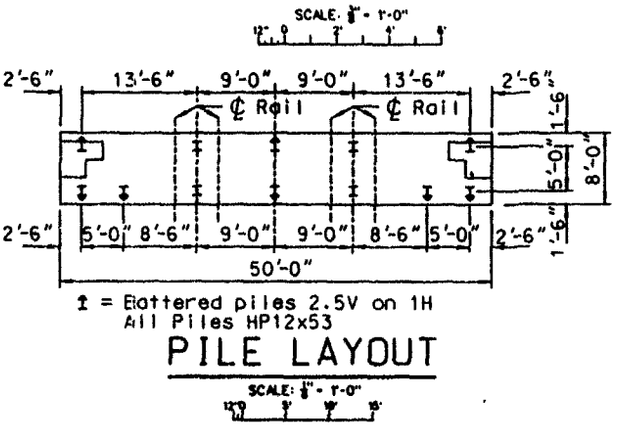


ATION

Gate closed. Center Support in place.
Sheet piling Cutoff Wall not shown.
Bearing Piles not shown.



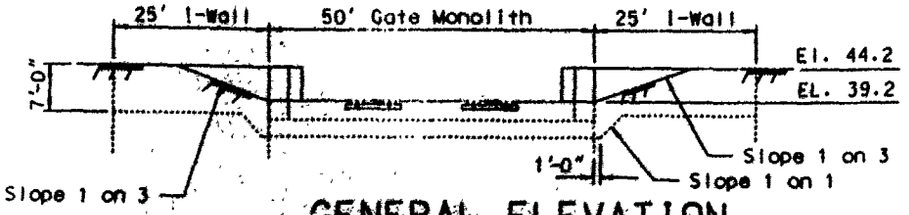
TYPICAL SECTION



‡ = Flattered piles 2.5V on 1H
All Piles HP12x53

PILE LAYOUT

SCALE: 1/8" = 1'-0"



GENERAL ELEVATION

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:

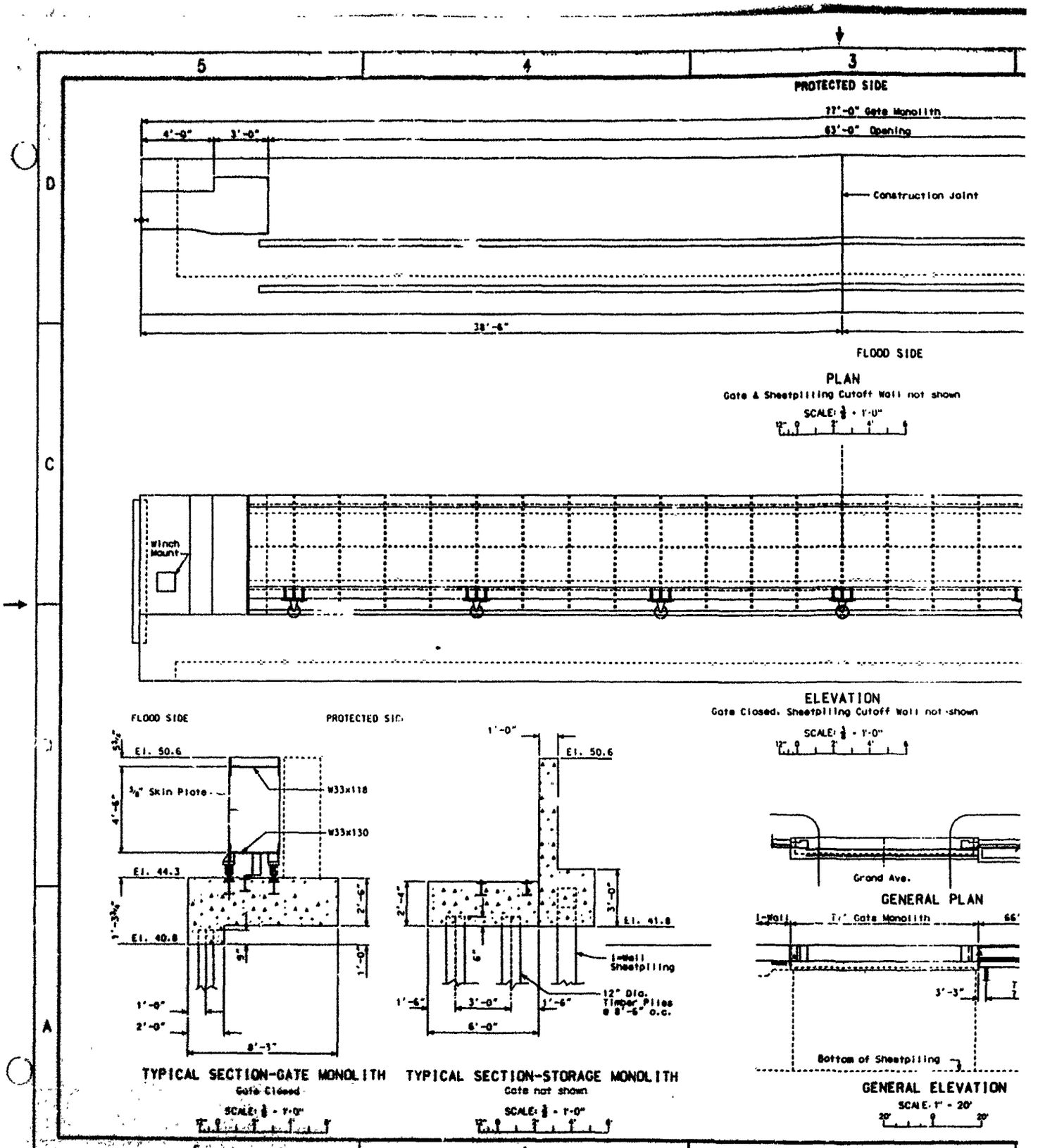
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

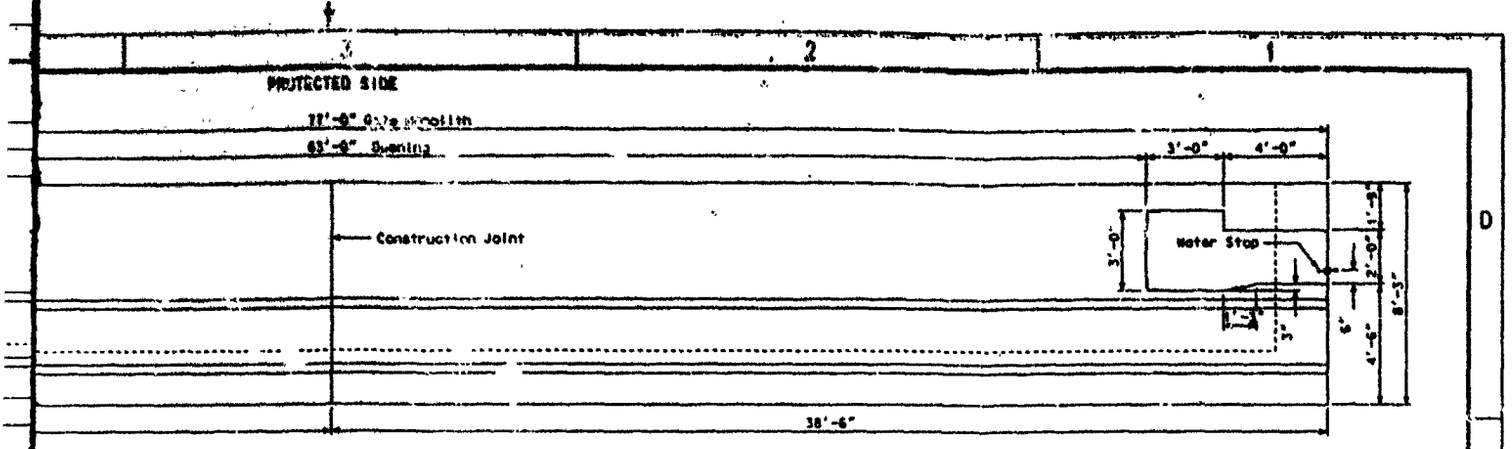
CHICAGO AND NORTHWESTERN RAILROAD CLOSURE

Scale: AS SHOWN
Date:
Drawing No.:
Sheet No.:
Contract Number:
Sheet of

PLATE 41

(B)

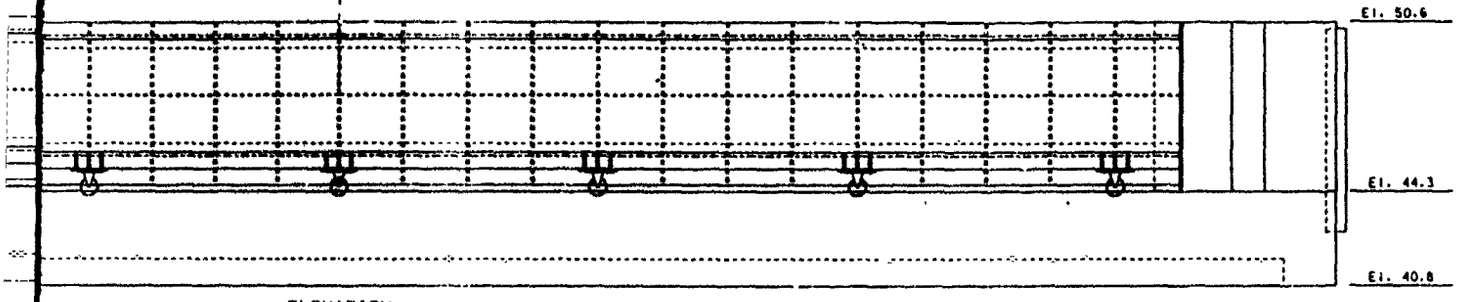

PROTECTED SIDE
77'-0" Gate Monolith
63'-0" Opening
4'-0"
3'-0"
Construction Joint
38'-6"
FLOOD SIDE
PLAN
Gate & Sheetpiling Cutoff Wall not shown
SCALE: 1/8" = 1'-0"
Winch Mount
ELEVATION
Gate Closed, Sheetpiling Cutoff Wall not shown
SCALE: 1/8" = 1'-0"
FLOOD SIDE
PROTECTED SIDE
El. 50.6
3/8" Skin Plate
W33x118
W33x130
El. 44.3
El. 40.8
1'-0"
2'-0"
8'-1"
TYPICAL SECTION-GATE MONOLITH
Gate Closed
SCALE: 1/8" = 1'-0"
1'-0"
El. 50.6
El. 41.8
I-Wall Sheetpiling
12" Dia. Timber Piles @ 8'-6" o.c.
1'-6"
3'-0"
6'-0"
TYPICAL SECTION-STORAGE MONOLITH
Gate not shown
SCALE: 1/8" = 1'-0"
Grand Ave.
GENERAL PLAN
I-Wall
77' Gate Monolith
66'
3'-3"
Bottom of Sheetpiling
GENERAL ELEVATION
SCALE: 1" = 20'
20'
20'



PLAN

Gate & Sheetpiling Cutoff Wall not shown

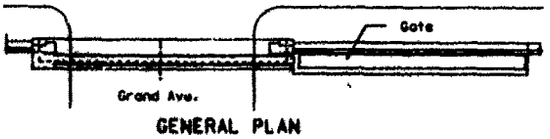
SCALE: 1/8" = 1'-0"



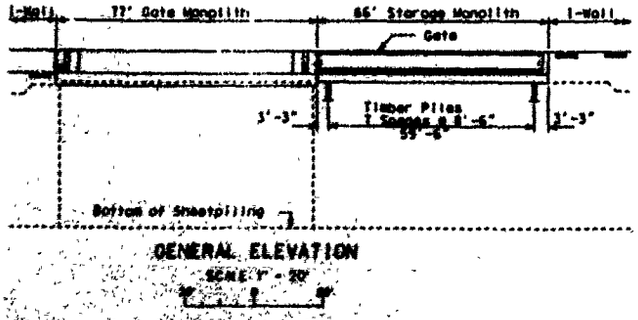
ELEVATION

Gate Closed, Sheetpiling Cutoff Wall not shown

SCALE: 1/8" = 1'-0"



GENERAL PLAN



GENERAL ELEVATION

SCALE: 1" = 20'

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

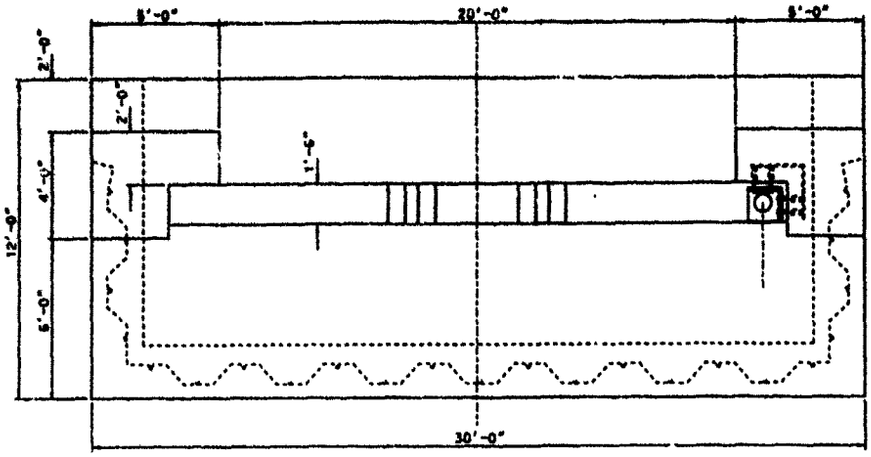
Designed by: J.G.B.
Drawn by: J.R.K.
Checked by:
Reviewed by:
Approved by:

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

GRAND AVENUE
CLOSURE STRUCTURE

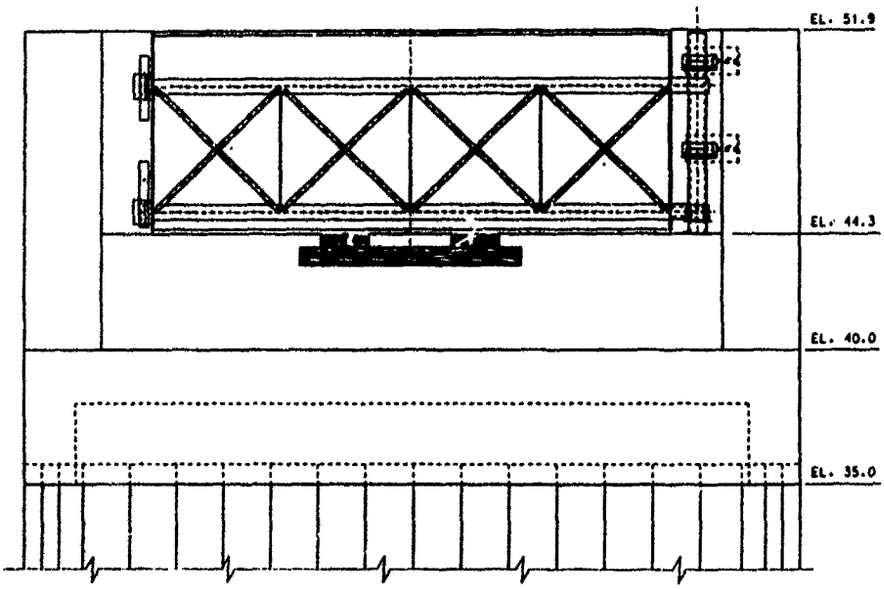
Scale: As Shown
Date:
Drawing Number:
Sheet of

PLATE 42

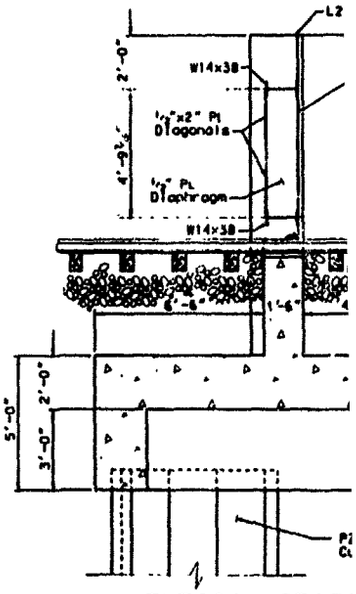


PLAN

SCALE: 1/8" = 1'-0"

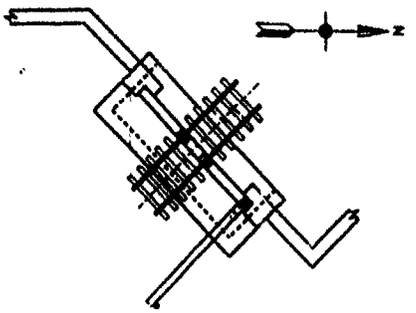


ELEVATION



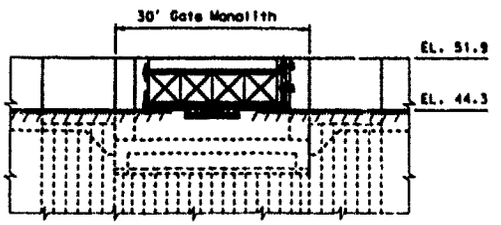
TYPICAL SECTI

A

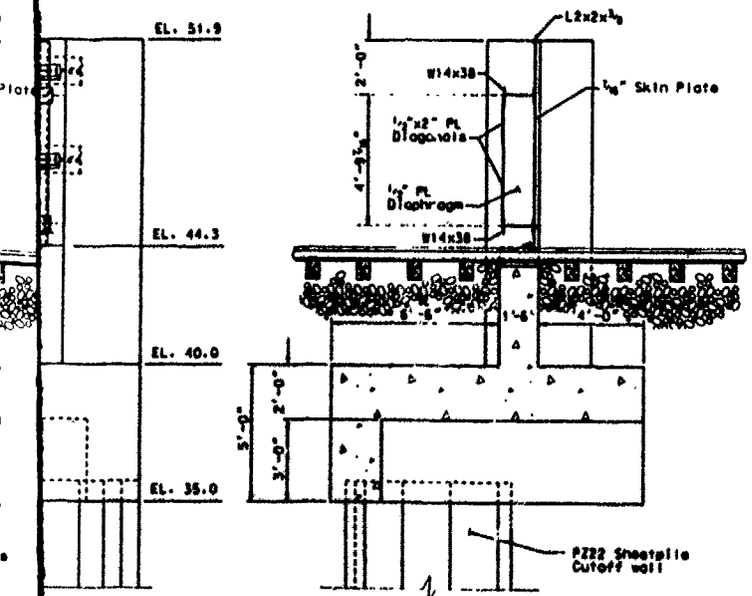


GENERAL PLAN

SCALE: 1" = 1'-0"



GENERAL ELEVATION



TYPICAL SECTION

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by: L.E.H.
Drawn by: R.D.G.
Checked by:
Traced by:
Approved by:

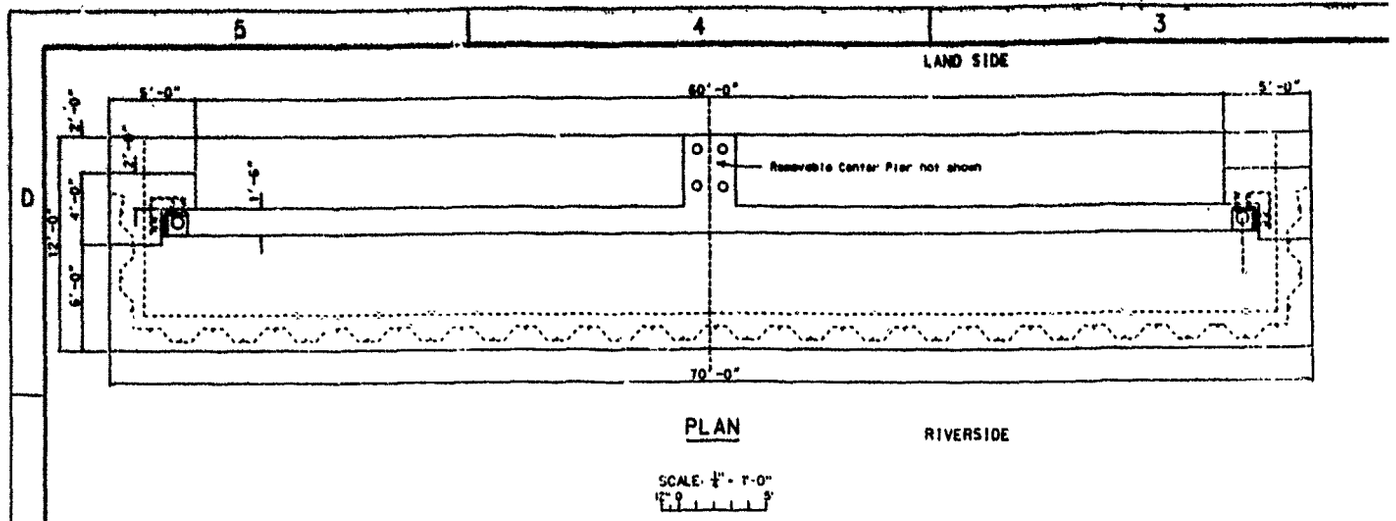
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

NORFOLK AND SOUTHERN
SINGLE TRACK
RAILROAD CLOSURE

Scale: AS SHOWN
Date:
Drawing No.:
Project No.:
Contract No.:
Sheet of

PLATE 43

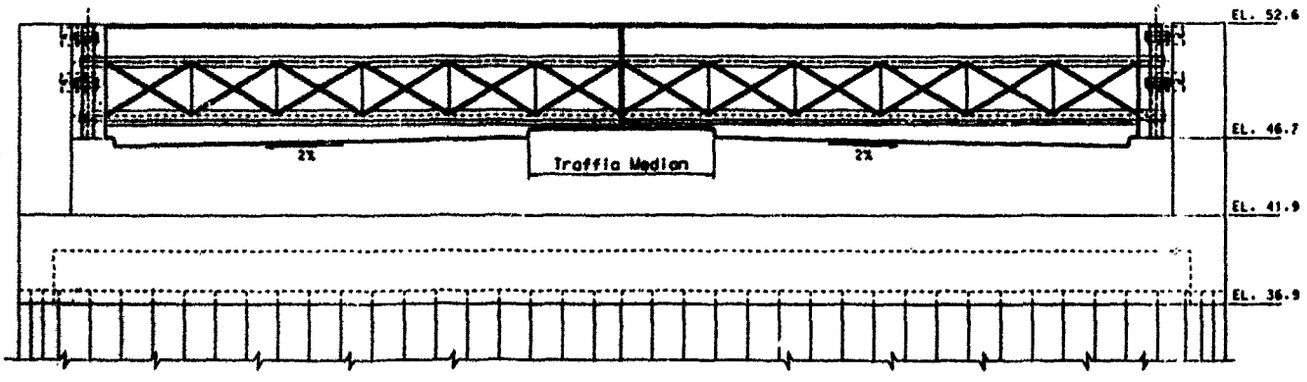
B



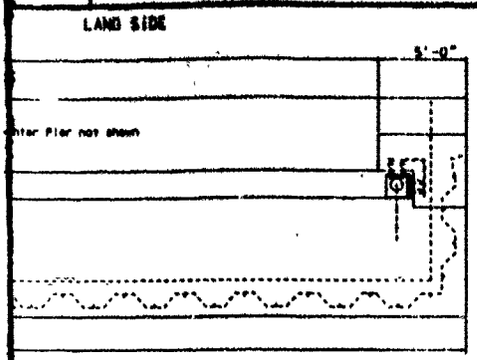
PLAN

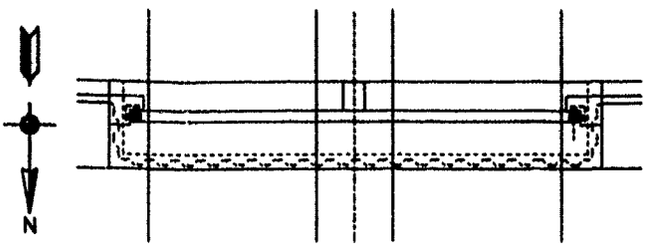
RIVERSIDE

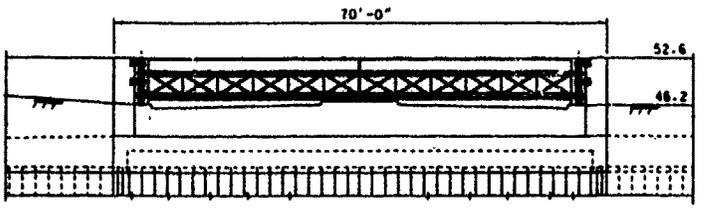
SCALE: 1/8" = 1'-0"



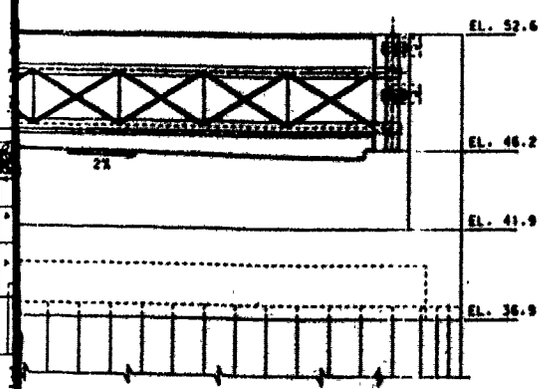
NORTH ELEVATION

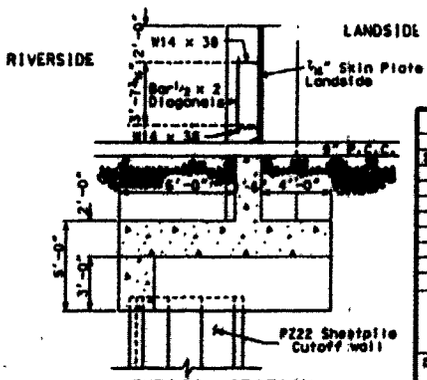






GENERAL PLAN
& NORTH ELEVATION
(STA. 192+70)
SCALE 1" = 10'





TYPICAL SECTION

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

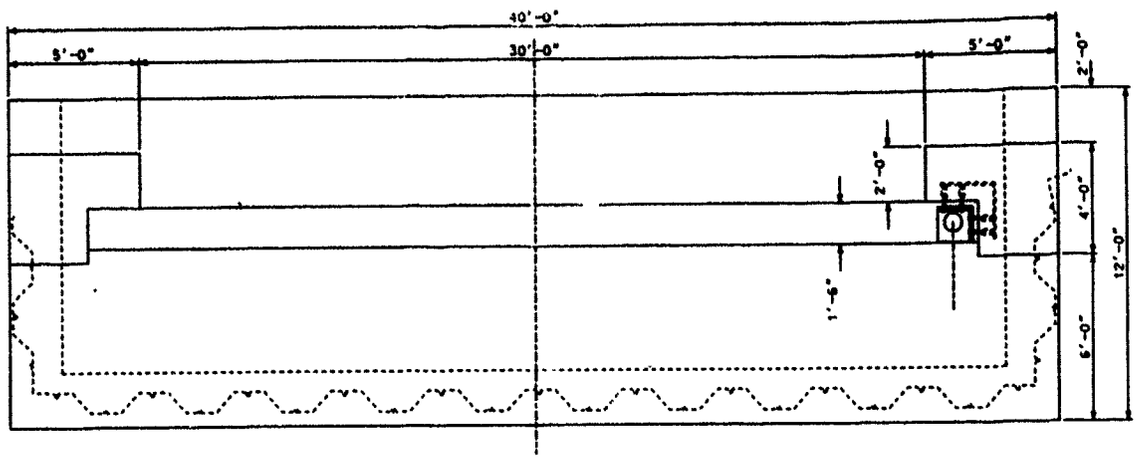
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

63 RD STREET
CLOSURE STRUCTURE

Designed by: K.E.H.
Drawn by: J.R.K.
Checked by:
Reviewed by:
Approved by:
Scale: AS SHOWN
Date:
Sheet of

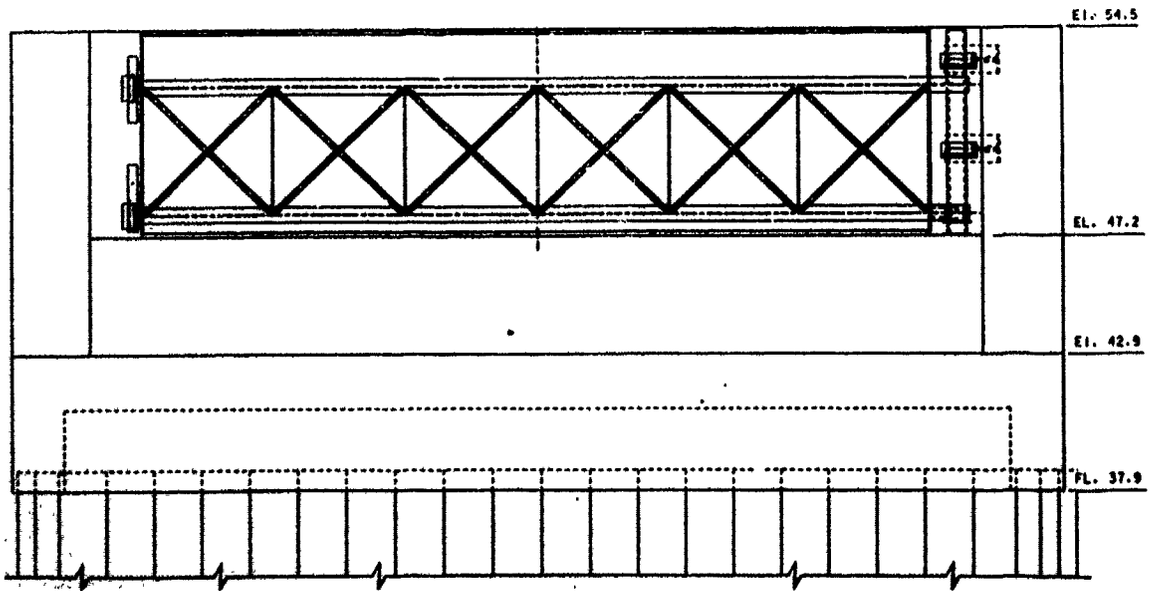
PLATE 44

B

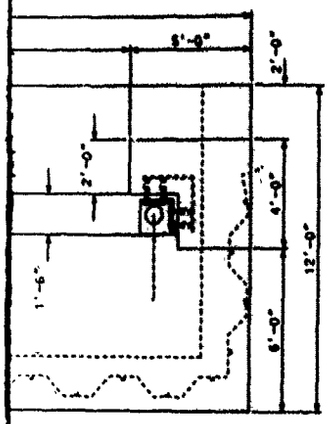


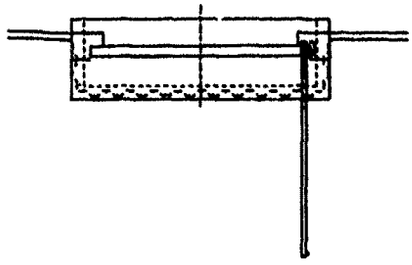
PLAN

SCALE: 1/8" = 1'-0"



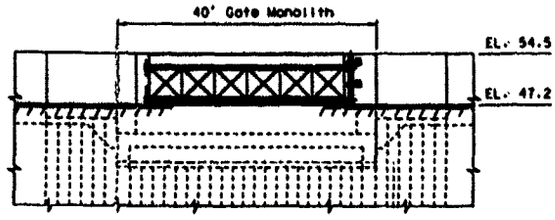
ELEVATION



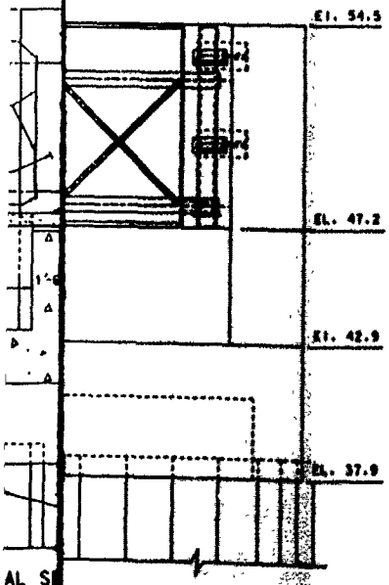


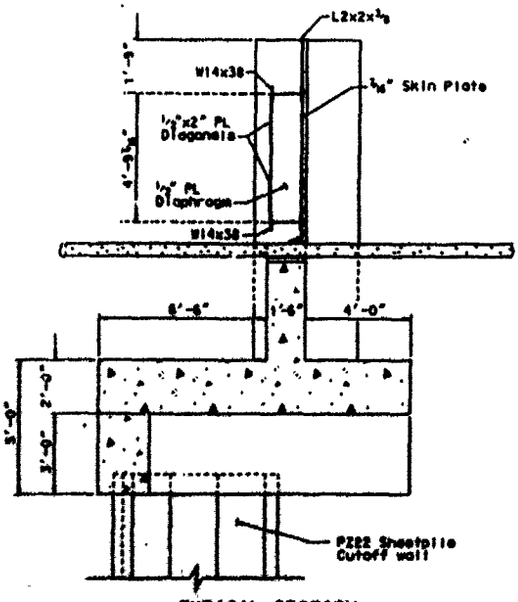
GENERAL PLAN

SCALE: 1" = 1'-0"



GENERAL ELEVATION





TYPICAL SECTION

Revisions		
Symbol	Description	Date Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by K.E.H.
Drawn by J.R.K.
Checked by
Reviewed by
Approved by

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

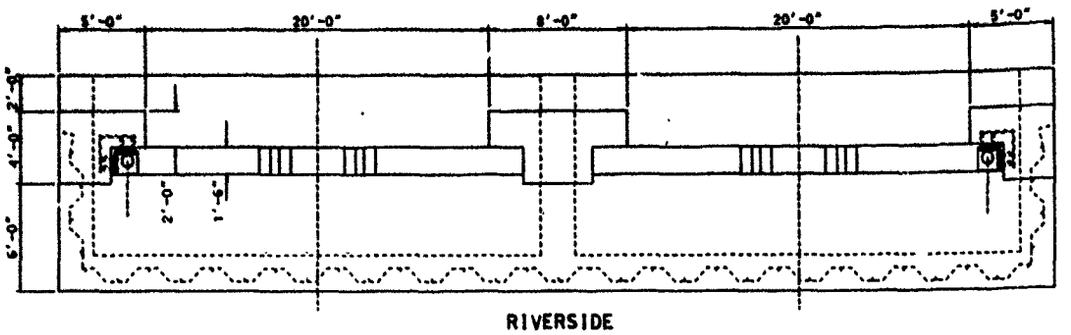
WHEELER LUMBER YARD
CLOSURE STRUCTURE

Scale: AS SHOWN
Date
Contract No.
Sheet of

PLATE 45

B

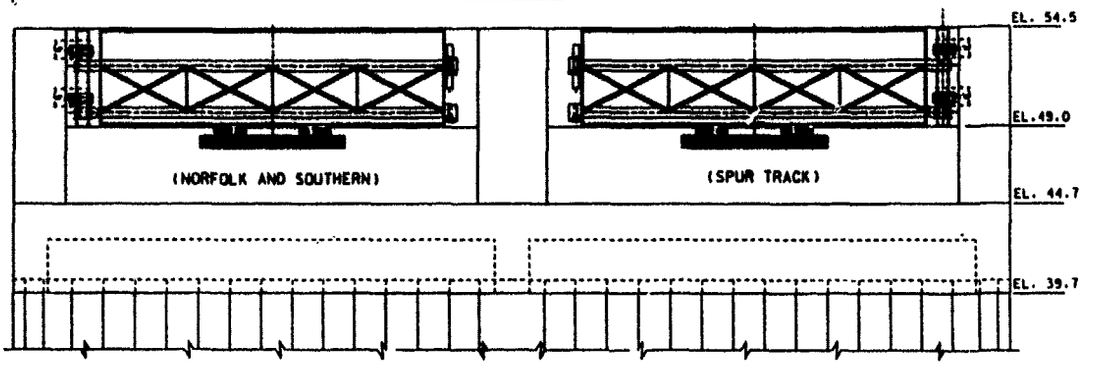
LANDSIDE



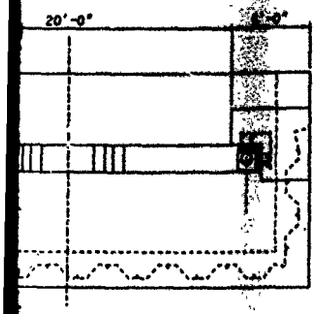
RIVERSIDE

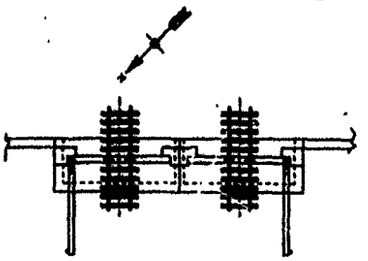
PLAN

SCALE: 1/8" = 1'-0"



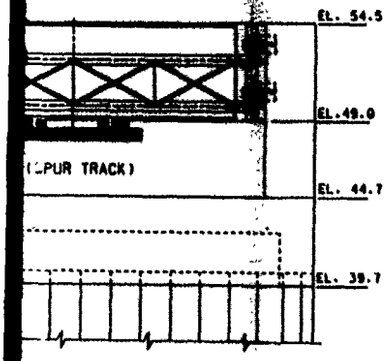
ELEVATION

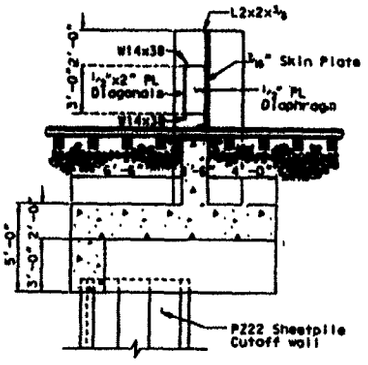




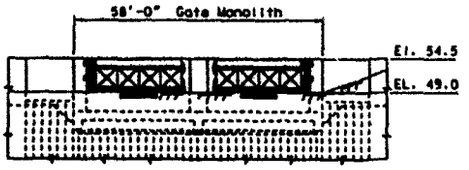
GENERAL PLAN

SCALE: 1" = 1'-0"





TYPICAL SECTION



GENERAL ELEVATION

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by: K.E.H.
Drawn by: J.R.K.
Checked by:
Reviewed by:
Approved by:

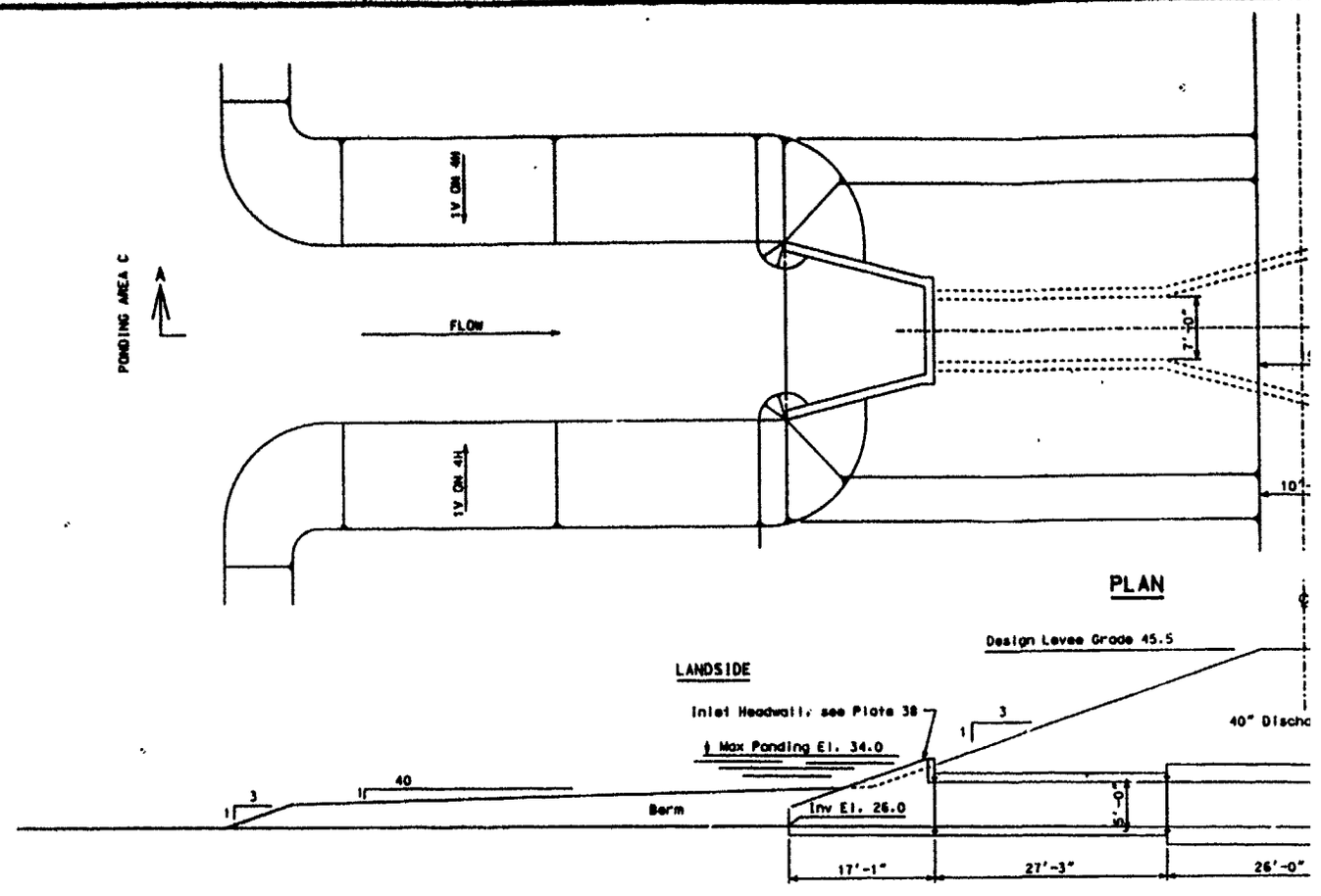
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

NORFOLK AND SOUTHERN
DOUBLE TRACK RAILROAD CLOSURE

Design: AS SHOWN
Drawing:
Sheet of

PLATE 46

B



PLAN

(STA. 81+50)

SECTION A-A

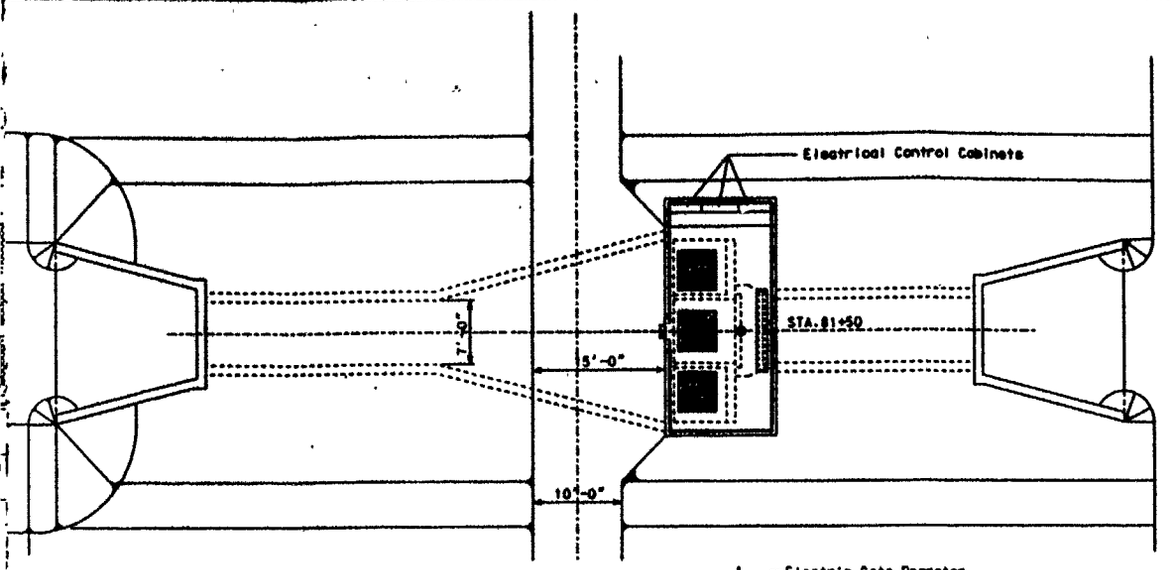
PERTINENT DATA

Design Levee Grade 45.5
Design Flood Profile 42.3
Minimum Pond elevation 26.0
Maximum Pond elevation 34.0
Top of Discharge pipe 46.0
Normal Riverside elevation 25.0

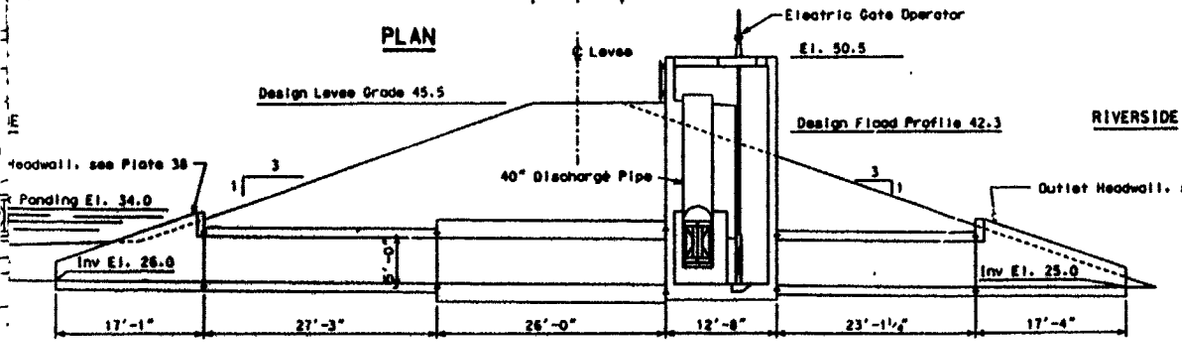
RACCOON RIVER PUMPING STATIO

PUMP OPERATION

UNIT	ON	OFF
Pump #1	29.5	29.0
pump #2	31.0	30.0
Pump #3	32.0	30.5



PLAN



(STA. 81+50)

SECTION A-A

REFERENCES:
1. For location, see plate 10.
2. For pump station electrical, see plate 48.

RACCOON RIVER PUMPING STATION

Symbol	Revisions Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by
Drawn by
Checked by
Reviewed by
Approved by

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

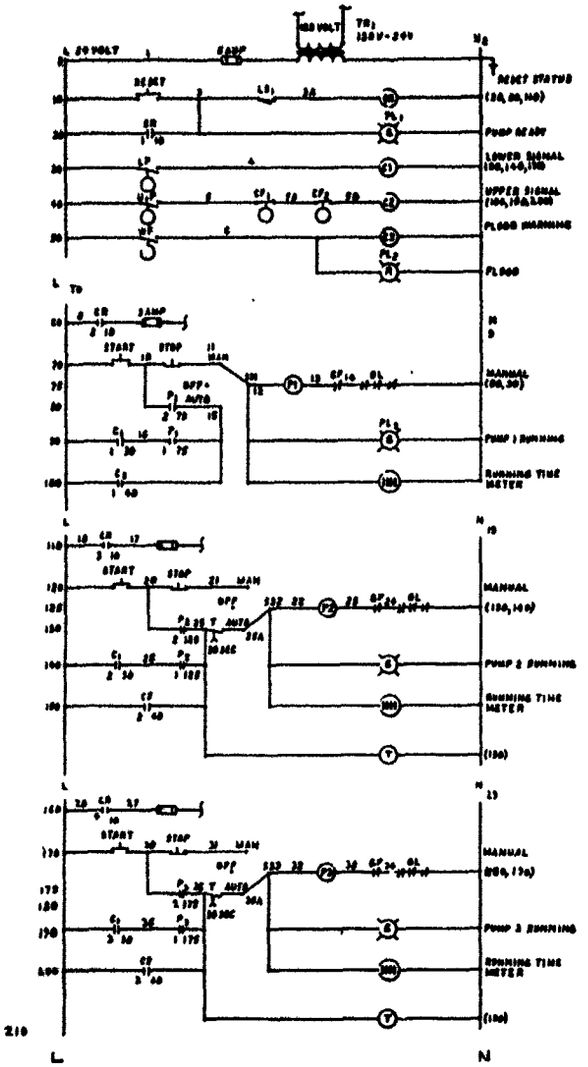
RACCOON RIVER
PUMPING STATION

Scale 1/8"=1'-0"
Date
Project Number
Sheet of

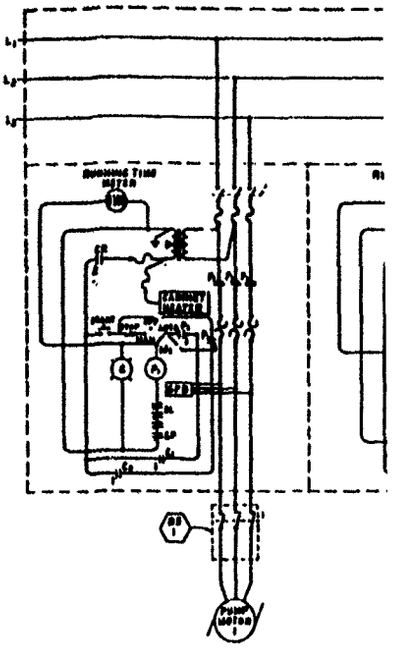
SCALE: 1/8" = 1'-0"

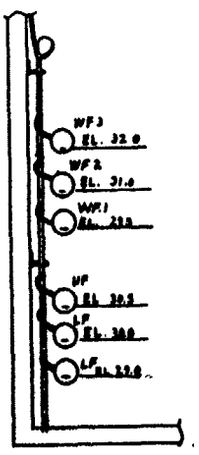
PLATE 47

B

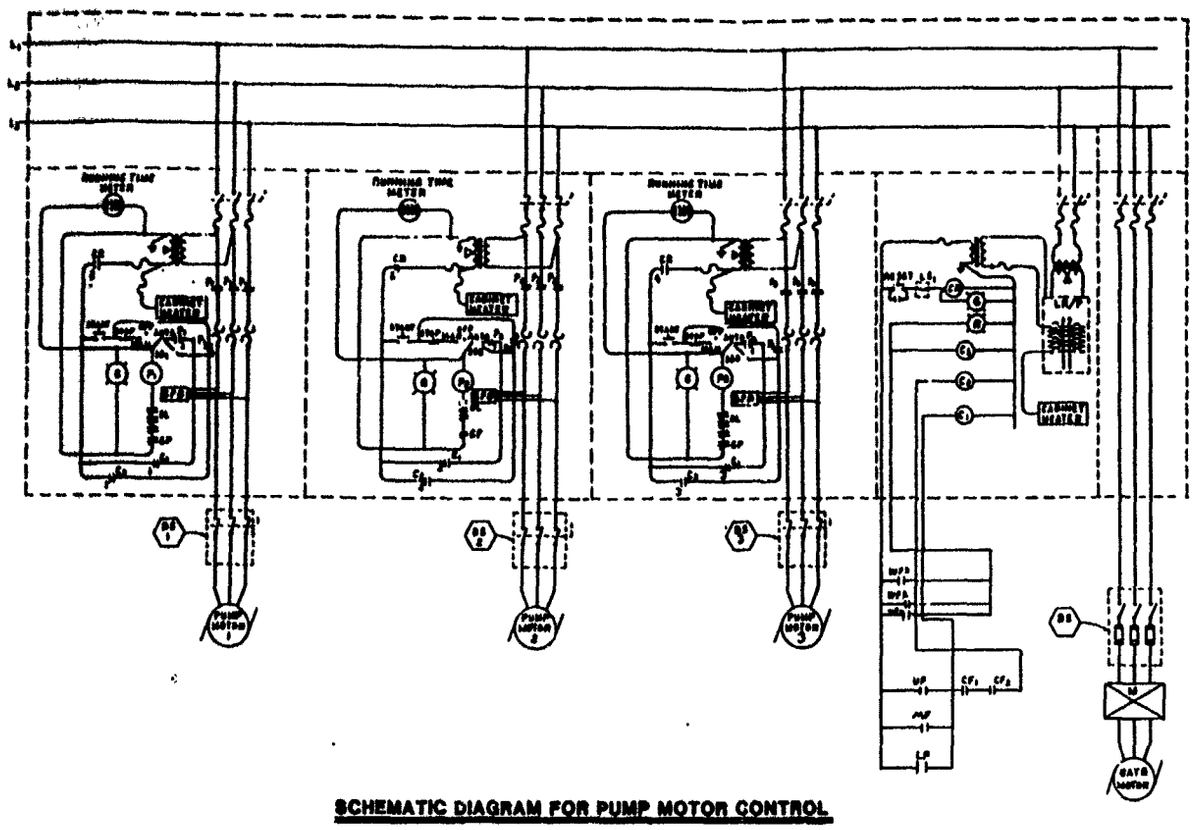


ELEMENTARY CONTROL DIAGRAM

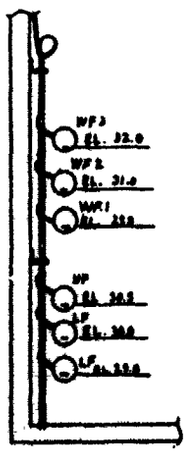




FLOAT SWITCH



SCHEMATIC DIAGRAM FOR PUMP MOTOR CONTROL



FLOAT SWITCH

Revisions			
Symbol	Descriptions	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

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Drawn by
Checked by
Reviewed by
Approved by

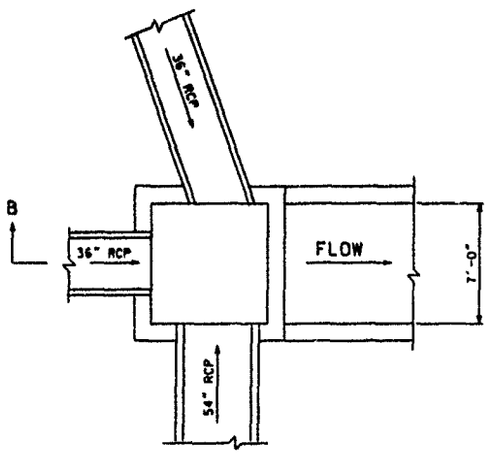
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

RACCOON RIVER PUMPING STATION
ELECTRICAL DIAGRAM

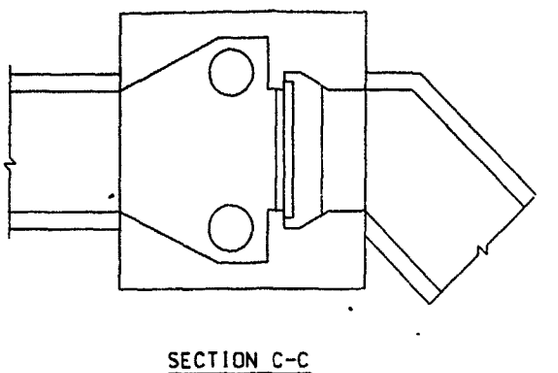
Scale
Date
Drawing number
Sheet reference numbers
Sheet ___ of ___

PLATE 48

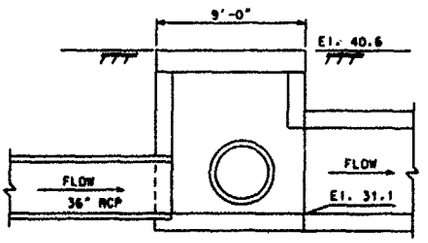
B



PLAN

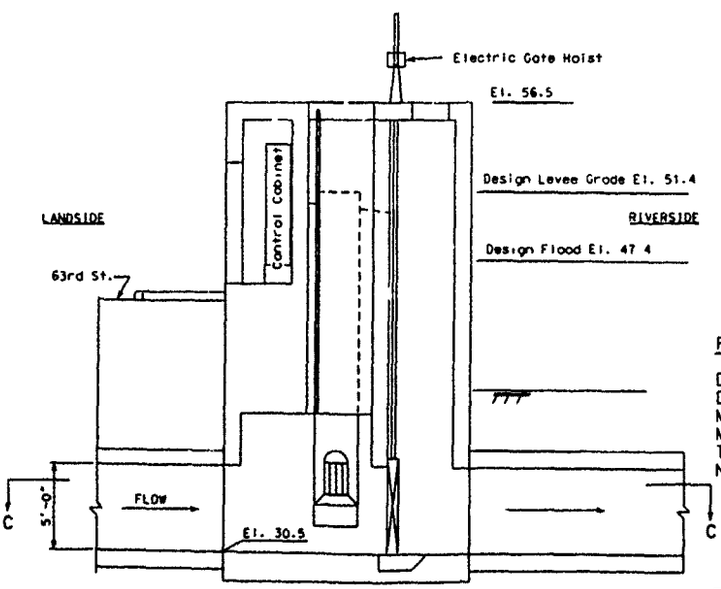


SECTION C-C



SECTION B-B

JUNCTION BOX

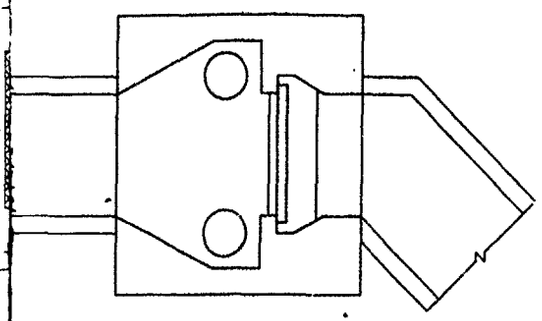


(STA. 187+82.2)

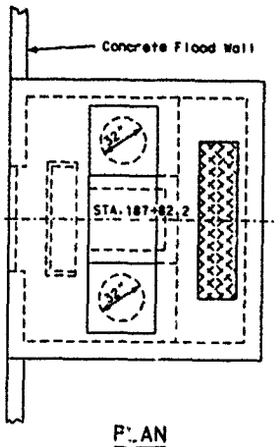
GRAND AVENUE PUMPING STATION

Per
Des
Des
Min
Max
Top
Nor

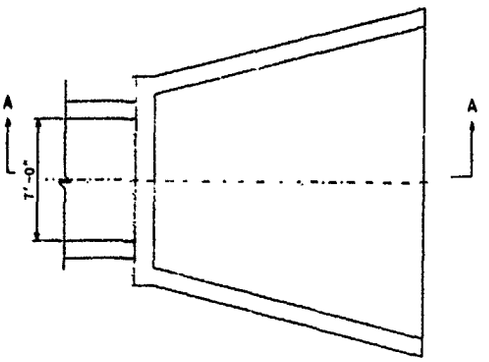
Pum
Uni
Pum
Pum

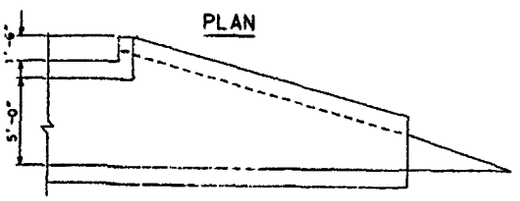


SECTION C-C



PLAN

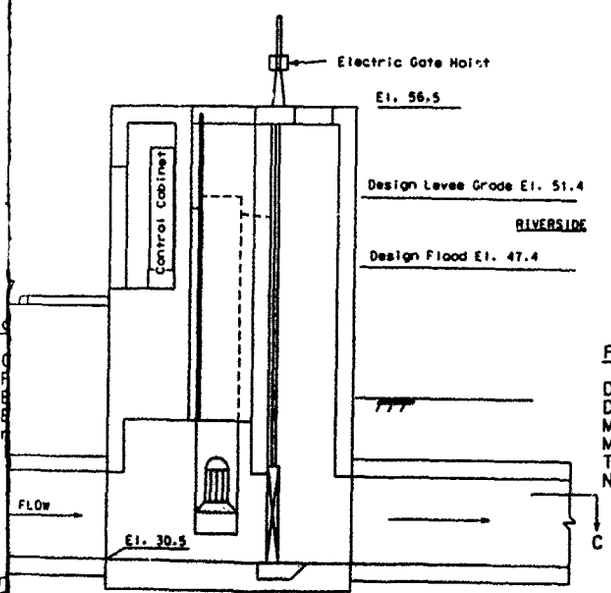




SECTION A-A

OUTLET HEADWALL

REFERENCES:
1. FOR LOCATION, SEE PLATE 19.
2. FOR HEADWALL DIMENSIONS, SEE PLATE 30.
3. FOR PUMPING STATION ELECTRICAL, SEE PLATE 50.



(STA.187+82.2)

GRAND AVENUE PUMPING STATION

Pertinent Data

Design Levee Grade 51.4
Design Flood Profile 47.4
Minimum Pond Elevation 33.0
Maximum Pond Elevation 41.0
Top of Discharge Pipe 47.9
Normal Riverside Elevation 28.4

Pump Operation

Unit	On	Off
Pump #1	35.0	33.0
Pump #2	36.0	33.5

SCALE: 1" = 1'-0"

Revisions			
Symbol	Description	Date	Approved

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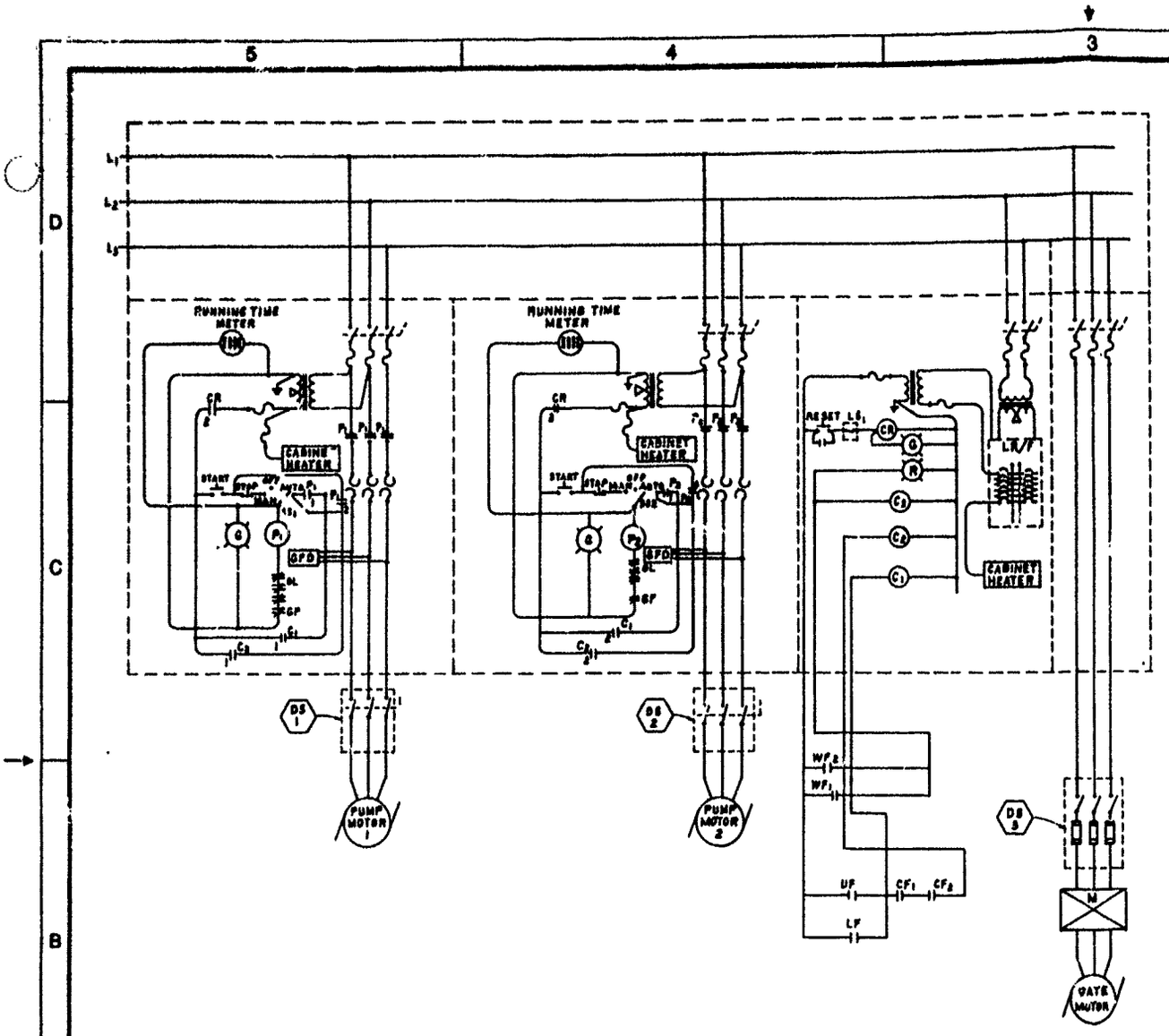
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Checked by:
Reviewed by:
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RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

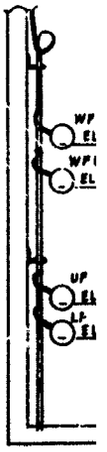
WALNUT CREEK
PUMPING STATION

Scale 1/4"=1'-0"
Date:
Drawing Code:
Sheet Reference Number:
Sheet of

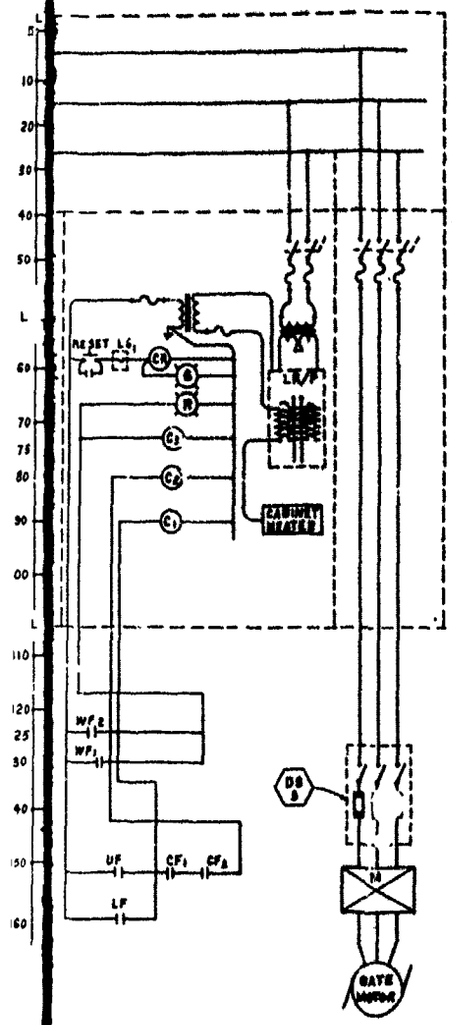
PLATE 49



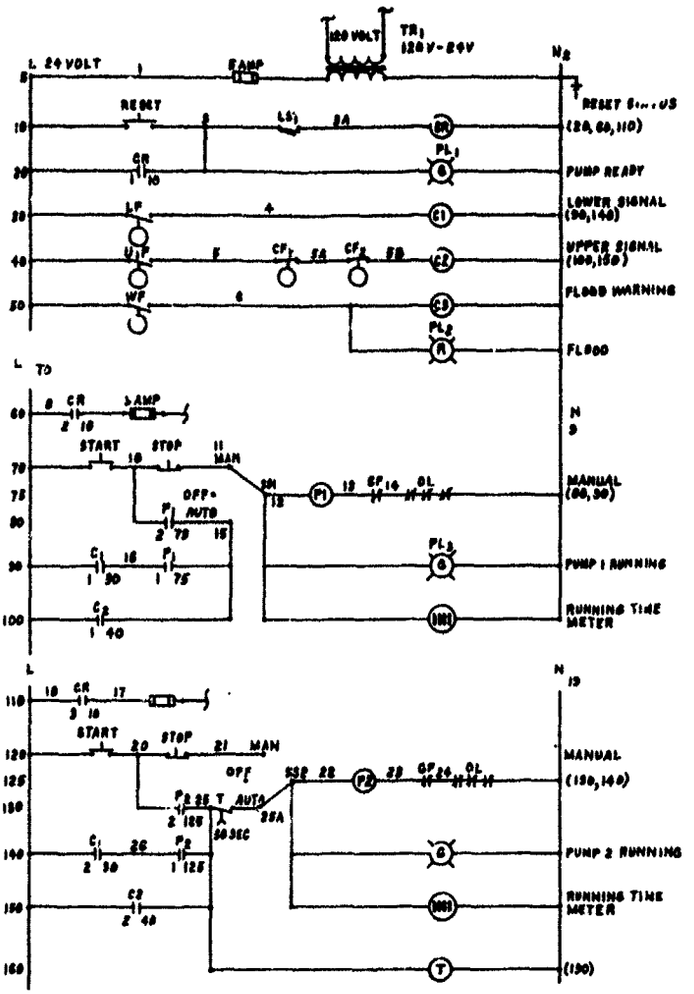
SCHEMATIC DIAGRAM FOR PUMP MOTOR CONTROL



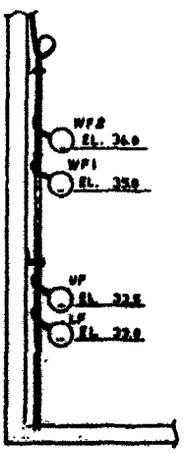
FLOAT



CONTROL



ELEMENTARY CONTROL DIAGRAM



FLOAT SWITCH

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CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION
WALNUT CREEK PUMPING STATION
ELECTRICAL DIAGRAM

PLATE 50

B

UTILITIES SCHEDULE

GAS - WATER - POWER - TELEPHONE

STATION	EXISTING FACILITY	DISPOSITION	RESPONSIBILITY	
9+90.5	FIBER OPTICS CABLE	SUPPORT AS REQUIRED DURING EXCAVATION OF EXPLORATION TRENCH	BY OTHERS	COORDINATION WITH OWNE
10+10.69'L	ABANDONED POLE	TO BE REMOVED	BY OTHERS	COORDINATION WITH OWNE
10+60	6"WATER LINE	REMOVE AND REPLACE WITH D.I.P. (MECHANICAL JOINT) AND INSTALL NEW VALVE	BY OTHERS	COORDINATION WITH OWNE
12+10.37'R	BURIED TELEPHONE CABLE BOX	NO WORK REQUIRED		
20+14.42'R	WATER MANHOLE	NO WORK REQUIRED		
23+00 TO 36+50	6 WATER LINE	NO WORK REQUIRED		
25+68.44'R	6"WATER LINE VALVE	NO WORK REQUIRED		
27+50.48'R	FIRE HYDRANT	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
35+32.69 R	4"WATER LINE W/VALVE	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
36+46.76 R	FIRE HYDRANT	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
38+45.77'R	3"GAS LINE	80L F TO BE REROUTED OVER THE TOP OF THE LEVEE	BY OTHERS	COORDINATION WITH OWNE
41+34.224'R	POWER POLE	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
41+72 TO 43+63	3"GAS LINE	280L F TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
68+07 TO 70+00	TELEPHONE LINE (OVERHEAD)	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
90+58	8"GAS LINE	NO WORK REQUIRED		
90+70	24"WATER LINE	INSTALL VALVE & REPLACE 60L F OVER THE TOP OF LEVEE	BY OTHERS	COORDINATION WITH OWNE
102+XX	FIBER OPTICS CABLE	SUPPORT AS REQUIRED DURING CONSTRUCTION	BY OTHERS	COORDINATION WITH OWNE
102+XX	FIBER OPTICS CABLE	SUPPORT AS REQUIRED DURING CONSTRUCTION	BY OTHERS	COORDINATION WITH OWNE
147+60	6"GAS LINE	NO WORK REQUIRED		
177+42.129 R	24" WATER LINE	INSTALL VALVE & REPLACE 50L F OVER THE TOP OF LEVEE	BY OTHERS	COORDINATION WITH OWNE
177+97.116 R	BURIED TELEPHONE CABLE	SUPPORT AS REQUIRED DURING CONSTRUCTION OF WALL	BY OTHERS	COORDINATION WITH OWNE
178+44.104'R	BURIED TELEPHONE CABLE	SUPPORT AS REQUIRED DURING CONSTRUCTION OF WALL	BY OTHERS	COORDINATION WITH OWNE
178+00 TO 183+25	8"GAS LINE	NO WORK REQUIRED		
182+09.98'R	ELECTRICAL MANHOLE	NO WORK REQUIRED		
184+13.101'R	ELECTRICAL MANHOLE	NO WORK REQUIRED		
184+29.106'R	TRAFFIC SIGNAL	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
184+56.102'R	ELECTRICAL MANHOLE	NO WORK REQUIRED		
184+77.108'R	TELEPHONE MANHOLE	NO WORK REQUIRED		
184+84.108'R	TELEPHONE MANHOLE	NO WORK REQUIRED		
185+05.105'R	ELECTRICAL MANHOLE	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
185+11.101'R	TRAFFIC SIGNAL	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
185+14.103'R	GAS LINE	TO BE SUPPORTED DURING CONSTRUCTION OF WALL	BY OTHERS	COORDINATION WITH OWNE
185+18.106'R	SIGNAL BOX	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
185+22.102'R	POWER POLE W/LIGHT	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
187+64.109'R	POWER POLE W/LIGHT	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
188+77.108'R	POWER POLE W/LIGHT	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
189+32.107'R	R R SIGNAL	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
189+57.119'R	R.R TELEGRAPH POLE	NO WORK REQUIRED		
190+14.108'R	POWER POLE W/LIGHT	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
191+47.108'R	POWER POLE W/LIGHT	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
192+72.106'R	POWER POLE W/LIGHT	NO WORK REQUIRED		
197+34.92'L	POWER POLE	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
200+89.7'L	POWER POLE	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
202+00 TO 215+XX	6"WATER LINE (3 HYDRANTS)	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
206+56.32 L	POWER POLE W/LIGHT	NO WORK REQUIRED		
208+49.19'L	POWER POLE	NO WORK REQUIRED		
209+12.28'L	POWER POLE	NO WORK REQUIRED		
210+06.34'L	VALVE M.H (1"WATER LINE)	NO WORK REQUIRED		
211+78.26'L	POWER POLE W/LIGHT	NO WORK REQUIRED		
212+99.26'L	POWER POLE	NO WORK REQUIRED		
214+52.31'L	POWER POLE	TO BE RELOCATED	BY OTHERS	COORDINATION WITH OWNE
219+38.30'L	POWER POLE	NO WORK REQUIRED		
220+20.27'L	POWER POLE	NO WORK REQUIRED		
221+88.2'R	POWER POLE	NO WORK REQUIRED		

5 4 3

D C B A

A

TIES SCHEDULE

ATER - POWER - TELEPHONE

	RESPONSIBILITY	REMARKS	SHEET NO.
ATION TRENCH	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION (SPRINT)	4
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	4
AND INSTALL NEW VALVE	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	4
			5
			5
			5&6
			6
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	6
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	6
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	7
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	7
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	7
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	7
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	7
			11
EE	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	11
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION (SPRINT)	12
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION (U.S.WEST)	12
			13
EE	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
			13
			13
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
			13
			13
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	13
			20
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	20
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	20
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	20&21
			21
			21
			21
			21
			21
	BY OTHERS	COORDINATION WITH OWNER DURING CONSTRUCTION	21
			22
			22
			22

Revisions			
Symbol	Description	Date	Approved

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CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

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Drawn by:
Checked by:
Reviewed by:
Approved by: JOHN R. BRYAN COL, CORPS OF ENGINEERS

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

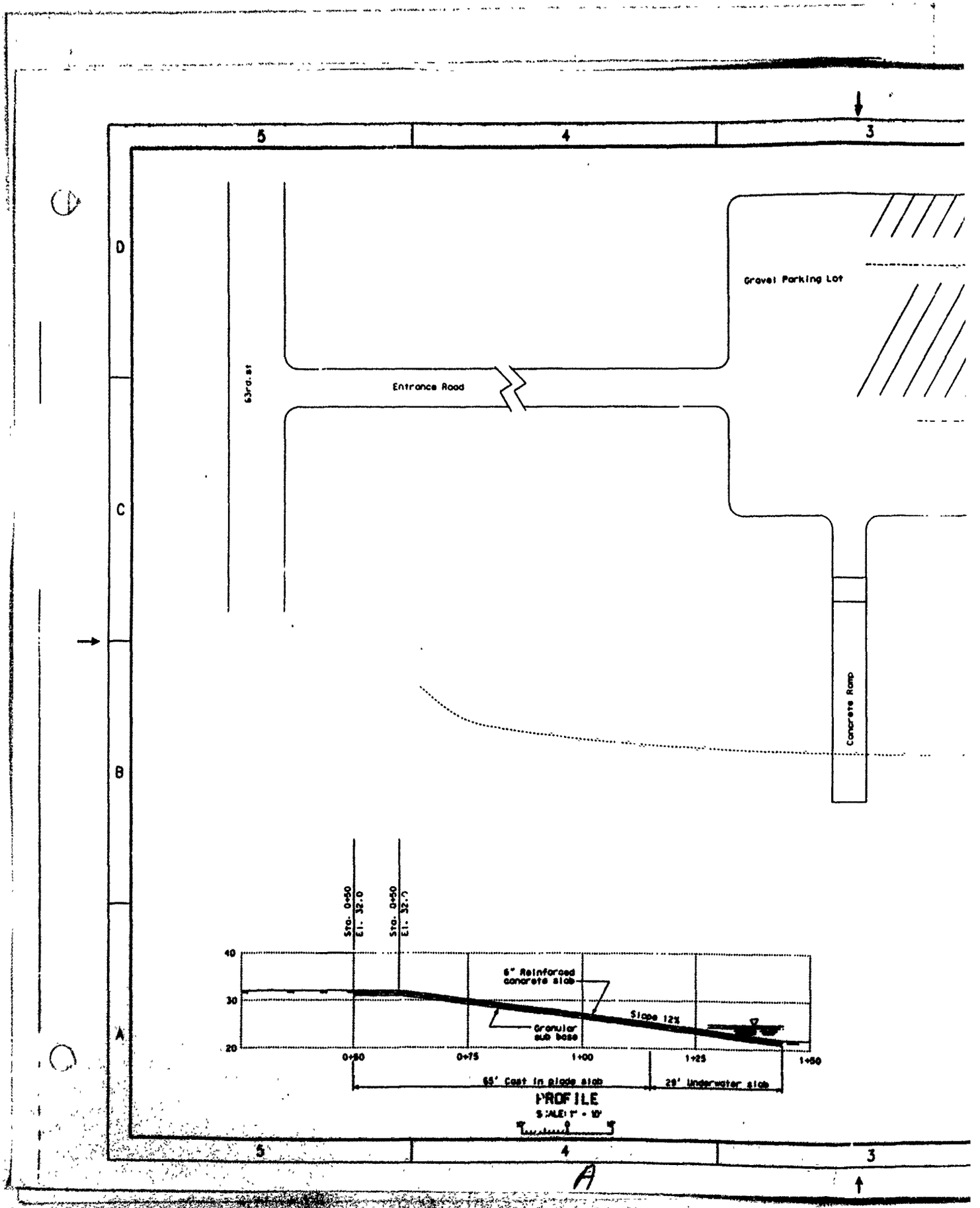
UTILITIES SCHEDULE

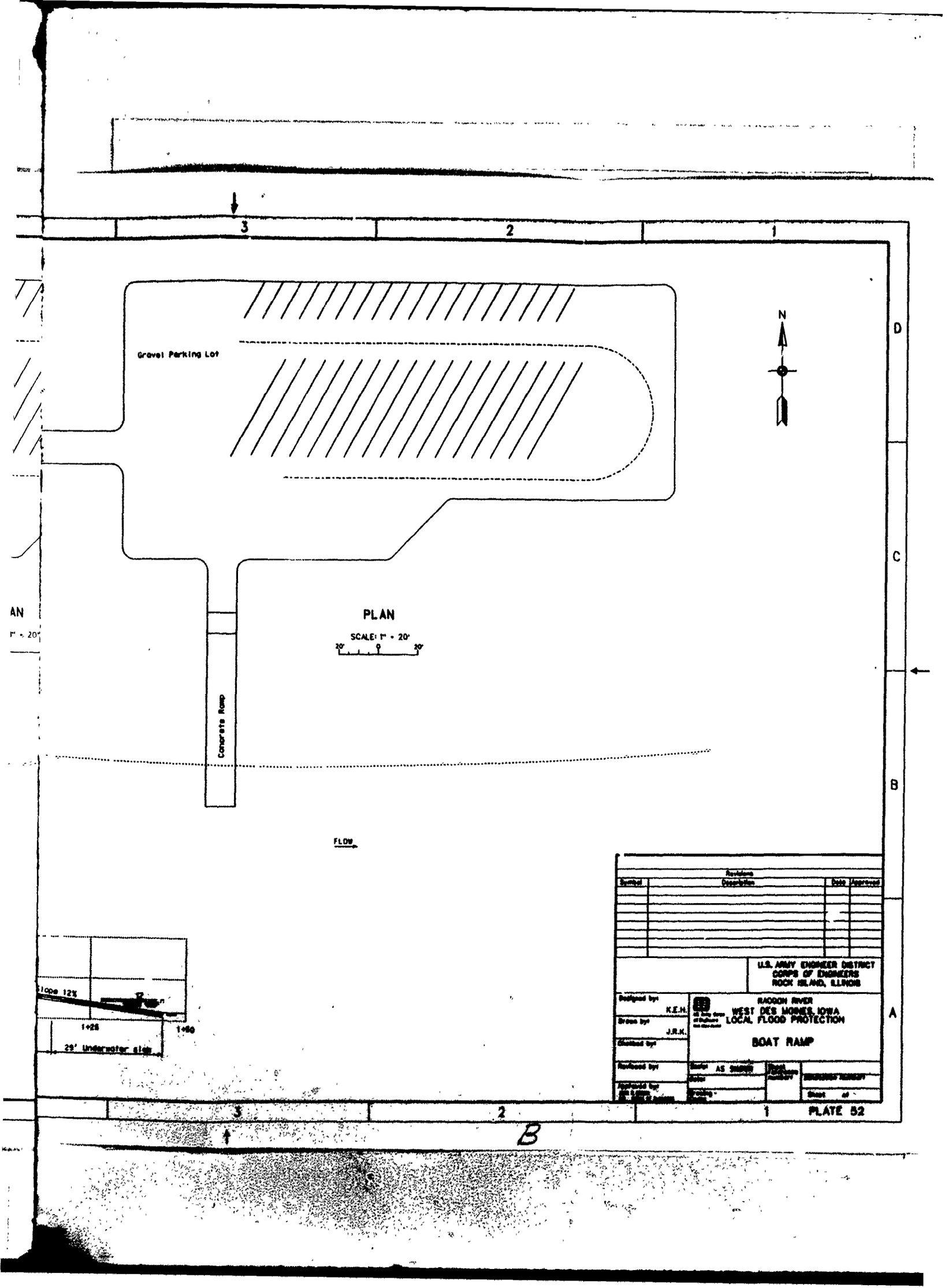
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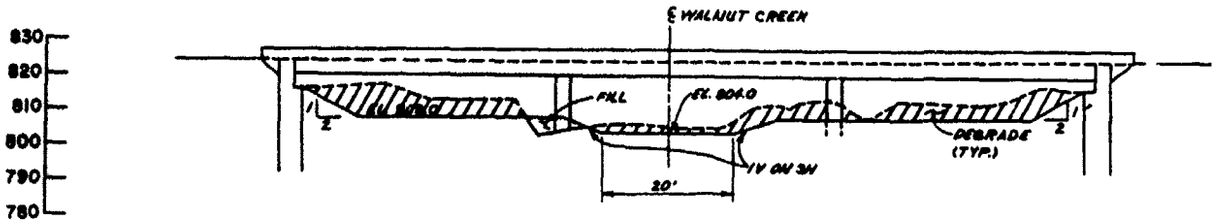
PLATE 51

3 2 1

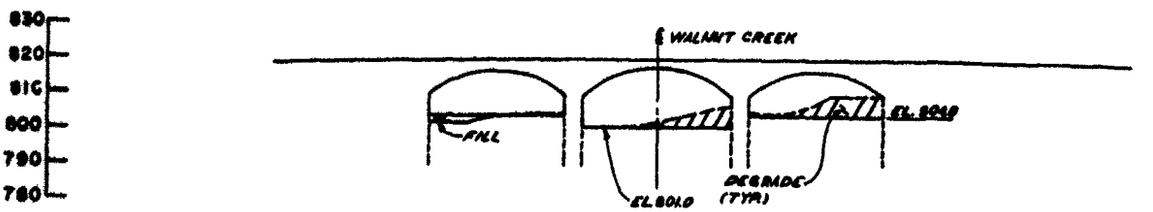
B


5
4
3
D
C
B
A
63rd. st
Entrance Road
Gravel Parking Lot
Concrete Ramp
Sta. 0+50
El. 32.0
Sta. 0+50
El. 32.0
40
30
20
6" Reinforced concrete slab
Granular sub base
Slope 12%
0+50
0+75
1+00
1+25
1+50
65' Cast in place slab
29' Underwater slab
PROFILE
SCALE: 1" = 10'


3
2
1
D
C
B
A
N
Gravel Parking Lot
PLAN
SCALE: 1" = 20'
20' 0 20'
Concrete Ramp
FLOW
Slope 12%
1+25
1+50
29' Underwater slope
Revisions
Symbol
Description
Date Approved
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS
Designed by K.E.H.
Drawn by J.R.K.
Checked by
Traced by
Approved by
Scale AS SHOWN
Date
RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION
BOAT RAMP
Sheet of
PLATE 52
B



63RD STREET BRIDGE



GRAND AVENUE BRIDGE

3 2 1

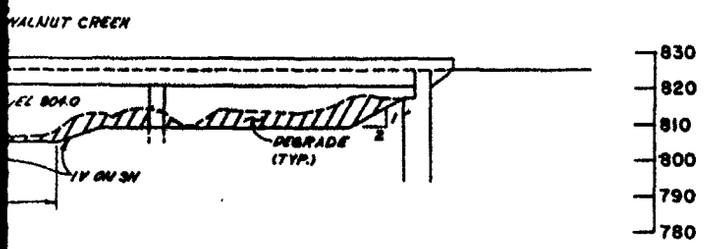
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63RD STREET BRIDGE

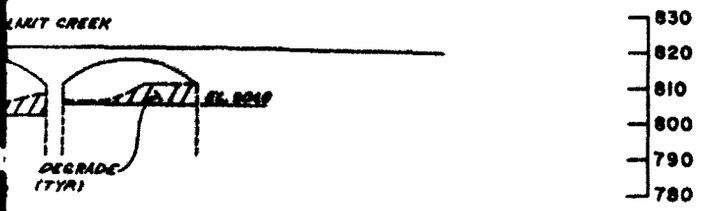
EXISTING OPENING	1000 SQ.FT.
CLEANOUT	500 SQ.FT.
IMPROVED OPENING	1500 SQ.FT.

GRAND AVENUE BRIDGE

EXISTING OPENING	625 SQ.FT.
CLEANOUT	125 SQ.FT.
IMPROVED OPENING	750 SQ.FT.



STREET BRIDGE



ENUE BRIDGE

NOTES:

1. THE CONTRACTOR SHALL EXCAVATE SILTATION FROM THE BRIDGES. MATERIAL WILL BE DISPOSED OF IN AN UPLAND DISPOSAL AREA.
2. THESE BRIDGE OPENINGS WILL NEED TO BE MAINTAINED BY THE CITY OF WEST DES MOINES TO PASS FUTURE FLOOD FLOWS.

VERTICAL SCALE

HORIZONTAL SCALE

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

RACCOON RIVER
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

WALNUT CREEK-
BRIDGE IMPROVEMENTS

Designed by
Drawn by
Checked by
Reviewed by
Approved by

Scale: AS SHOWN
Date
Drawing / Design File

Sheet reference number
Sheet ... of ...

PLATE 53

3 2 1

B

A

P

P

E

N

HYDRAULICS AND HYDROLOGY

D

I

X

A

DESIGN MEMORANDUM
FOR
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA

APPENDIX A
HYDROLOGY AND HYDRAULICS

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DESIGN MEMORANDUM
FOR
FLOOD CONTROL PROJECT
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA

APPENDIX A
HYDROLOGY AND HYDRAULICS

SECTION 1 - INTRODUCTION

GENERAL

This appendix presents the hydrologic and hydraulic analysis of the studied alternatives for the local flood protection of the Valley Junction areas of downtown West Des Moines and the surrounding floodplain areas in both Des Moines and West Des Moines, Iowa. The project area is subject to flooding from the Raccoon River, a major tributary stream of the Des Moines River, and from Walnut Creek and Jordan Creek, tributary streams to the Raccoon River. The protected project area includes 740 acres of residential, commercial, industrial, and public lands located in the 100-year floodplain. The project layout is shown on plate A-1. The Des Moines River confluence is located approximately seven miles downstream.

A Feasibility Study for Flood Damage Reduction and Related Purposes -Des Moines River Basin (Reference A) was completed in June 1975 by the Rock Island District. The project had not progressed since then due to a lack of post-authorization funding until the 1986 Water Resources Act reactivated the project.

The 1986 Water Resources Act resulted in a General Reevaluation Report (GRR) for Flood Control Project, Raccoon River and Walnut Creek, West Des Moines - Des Moines, Iowa (Reference S) of the authorized project. The July 1986 GRR reaffirmed economic feasibility for the project along with modifying levee alignments to incorporate new flood plain regulations and developments since 1975. The plan selected for further development in the Design Memorandum phase as a result of the GRR was a 100-year level of flood protection from the Raccoon River and Walnut Creek.

CLIMATOLOGY

Central Iowa has a humid continental climate; average summers are hot and humid and winters are cold and relatively dry. The seasonal distribution of average annual precipitation is highly favorable for agriculture, with over 70 percent falling during the crop growing season. Most of Iowa's precipitation, both winter and summer, comes from warm, moist air masses moving

upward from the Gulf of Mexico. The prevailing southerly winds of spring and summer favor increased rainfall, while the dominance of cold polar air masses in winter often blocks the access of moist, tropical air to the region.

The average annual precipitation for central Iowa is 32 inches, with a normal annual snowfall of 31 inches. The five greatest recorded rainfalls at the nearby National Weather Service gage at the Des Moines Airport are listed in table A-1 for selected durations.

TABLE A-1

Five Greatest Recorded Rainfalls, Inches
Des Moines, Iowa
1/1/36 - 12/31/82

15-Minute		30-Minute		60-Minute		24-Hour(1878-1982)	
1.48	6-10-62	1.77	6-23-81	2.53	6-23-81	6.18	8-27-75
1.28	7- 3-73	1.74	8- 1-72	2.36	8-27-75	5.37	6-11-47
1.27	8- 1-72	1.72	7-14-42	2.36	7-14-42	5.14	7- 1-58
1.24	8-14-81	1.69	7- 3-73	2.27	8-11-49	5.14	6-19-1881
1.20	6-23-81	1.64	8-26-77	2.27	8-14-81	4.87	9-16-14

The average yearly temperature in Des Moines is 49 degrees Fahrenheit (F), with the monthly average varying from a low of 21 degrees F in January to a high of 76 degrees F in July. The annual average number of consecutive freeze-free days is 165 days.

SECTION 2 - RACCOON RIVER, WALNUT CREEK, AND JORDAN CREEK FLOODING

GENERAL

RACCOON RIVER

The study area is located on the Raccoon River and Walnut Creek floodplains approximately seven miles upstream from the confluence with the Des Moines River. The Raccoon River has its headwaters in Buena Vista County in northwestern Iowa, and its watershed includes the ten west-central Iowa counties of Buena Vista, Calhoun, Carroll, Dallas, Greene, Guthrie, Pocahontas, Polk, Sac, and Webster. Land use in the basin is predominantly agricultural. The river flows southeasterly for 210 miles, with a total watershed area of 3,640 square miles. The average slope per mile of stream is 2.6 feet. The Raccoon River basin is shown on plate A-2.

The Raccoon River is a gaged stream. A USGS stream gage is located at Van Meter, Iowa (#05484500), with an upstream drainage area of 3,441 square miles. At Fleur Drive in Des Moines, the Des Moines Water Works has operated a staff gage since 1915. The city of Des Moines upgraded this gage in 1984 to a full service stream gage. Reliable rating curves and data are still in the process of development. The drainage area of the Raccoon River at the project site above Walnut Creek is 3,535 square miles.

WALNUT CREEK

The Walnut Creek watershed drains 82.4 square miles, with the basin lying in portions of Dallas and Polk Counties. The watershed is shown on plate A-3 with the area downstream from Interstate 35/80 being highly developed. The topography varies from nearly level in the upper reaches of the watershed to rolling terrain in the middle and lower areas of the basin.

Currently, development has started to "jump" over Interstate 35/80 to the west where commercial and residential development is on-going. It is evident that land-use changes are occurring in the middle of the watershed in the near future as shown on plate A-4. The annexations proposed by Clive, Urbandale and Waukee lie in the middle portion of the Walnut Creek watershed. These changes were considered in the project hydrology for Walnut Creek. Most of the upper portion of the basin is in agricultural use. In general, the basin consists of moderately to well-drained Clarion and Nicollet soils which are classified in hydrologic soil group B by the U.S. Soil Conservation Service.

Walnut Creek is a gaged stream with a USGS stream gage located immediately downstream of 63rd Street in Des Moines (#05484800) with an upstream area of 78.4 square miles. This gage has been in operation since October 1971.

JORDAN CREEK

Jordan Creek, a tributary to the Raccoon River, drains about ten square miles, as shown on plate A-3. The subbasins within the watershed exhibit a wide variety of land uses, ranging from undeveloped agricultural to highly urbanized. Nearly 70 percent of the watershed lies within the corporate limits of West Des Moines, with the remaining 30 percent in Dallas County. Continued urbanization is occurring throughout the watershed in West Des Moines. Additionally, the residential zoning of the unincorporated portion in Dallas County is an indication that the entire basin will become urbanized. West Des Moines city staff has stated that within the next ten years the Jordan Creek watershed will likely become completely developed. These

predicted land-use changes were considered in the project hydrology for Jordan Creek. The Dallas County area shown on plate A-4 lying between Interstate 80 and the Madison County line is where the headwaters of Jordan Creek are located. This area is presently being developed with executive acreages. The basin consists of moderately to well-drained soils which are classified in hydrologic soil group B.

Jordan Creek empties into the Raccoon River through a series of gravel pits which are located on the Raccoon River flood plain. The levee alignment lies about one-half mile landward from the Jordan Creek mouth. Thus, the gravel pits through which Jordan Creek reaches the Raccoon River do not effect project formulation. The Raccoon River floodplain is concurrent with the Jordan Creek floodplain up to the Chicago, Rock Island, and Pacific Railroad bridge. Between the railroad bridge and Fuller Road, spoil banks and levees exist along the right and left banks of the creek. The existing levees are not of constant grade and do not tie into high ground and therefore provide only limited flood protection. The low areas adjacent to these levees and along the railroad tracks appear subject to overflow backwater flooding during major Jordan Creek events. To date, there is no history of damaging floods occurring on Jordan Creek. Also, the stream is ungaged and no highwater data marks are available.

FLOODS OF RECORD

RACCOON RIVER

The flood of record at Van Meter, 41,200 cfs, occurred on June 12, 1947, which is approaching a 50-year peak flow. The third greatest recorded peak was a dependent crest which also occurred in June 1947 on the 25th. This secondary flood crested at 38,000 cfs. Table A-2 summarizes major Raccoon River floods.

On July 1, 1986, the Raccoon River crested at the Van Meter gage with a peak flow of 40,200 cfs. The river crested at 63rd Street in Des Moines the following day, about one foot below the 1973 flood. During the 1986 flood, lateral inflows to the Raccoon River were minimal between Van Meter and West Des Moines, thus resulting in some attenuation of the peak flows downstream of Van Meter. A temporary earthen levee was constructed along the Chicago and Northwestern Railroad in West Des Moines, thus keeping the project area from flooding. Aerial photography of the flood was taken on July 3rd, after the river had receded approximately 1.5 feet from the crest. No rainfall occurred on the interior areas when the river was flooding; however, city crews provided temporary pumping at the flapgated storm sewers to evacuate accumulated water from the interior.

Severe thunderstorms on June 16, 1990 over the lower Raccoon River basin resulted in flooding in the Des Moines area. A

Raccoon River peak flow of 32,800 cfs was recorded at Van Meter. Downstream lateral inflows pushed the peak flow up about 39,000 cfs when it reached Fleur Drive in Des Moines.

In 1973, the cities of Des Moines and West Des Moines incurred flood damages from the Raccoon River and Walnut Creek. The floods on the two streams resulted from the same storm system. The Walnut Creek flood crested on July 1, while flows on the Raccoon River were high from July 1-5, with the peak occurring on July 4, three days after the Walnut Creek crest. The 1973 Raccoon River flood was approximately a 25-year event and the fourth greatest occurrence recorded since 1915 at the Van Meter gaging station located 15 miles upstream from Des Moines. The recorded peak discharge at Van Meter was 35,600 cubic feet per second (cfs). Plate A-5 lists maximum flood peaks at all the gaging stations in the Raccoon River basin.

TABLE A-2

Summary of Major Floods
Raccoon River at Van Meter, Iowa

Peak Flow, cfs	Date of Occurrence
41,200	13 Jun 1947
40,200	1 Jul 1986
38,000	25 Jun 1947
35,600	4 Jul 1973
35,200	7 Jun 1917
35,200	3 Jul 1958
32,800	16 Jun 1990
32,300	2 Apr 1960
32,000	20 Sep 1926
29,900	19 Mar 1979

WALNUT CREEK

The earliest flood data available on Walnut Creek are from a flood event that occurred in 1947. Limited historical data in the form of highwater marks are also available from minor floods that occurred in 1958, 1961, 1964, and 1965. In October 1971, the USGS installed a stream gage on Walnut Creek immediately downstream of 63rd Street on the left overbank. Thus, little, if any, flood discharge data are available for floods that occurred prior to 1971.

In July 1973, heavy rainfalls over the entire basin resulted in flooding which exceeded any past historically documented flood levels. Although the gage at 63rd Street did not record the peak discharge during the flood, the USGS did use other techniques to estimate the peak discharge. Data indicate that a flood peak of

an estimated 9,000 cfs occurring at the 63rd Street location. Extensive ground and aerial photographs are available that document the flooding which occurred. An aerial photograph of the 63rd Street and Grand Avenue area is shown on plate A-6.

The flood of record occurred in May 1986 resulting from extremely heavy rainfalls in the upper Walnut Creek basin. The recorded peak discharge at the 63rd Street gage was determined to be 12,500 cfs. Highwater marks were set in the metropolitan area by both city and USGS staffs. This flood caused extensive flooding along the stream during the nighttime hours; therefore, no aerial photographs are available. Walnut Creek floods since the stream gage installation in 1971 are listed in table A-3.

TABLE A-3

Summary of Floods on Walnut Creek
October 1971 - Present

Peak Flow, cfs	Date of Occurrence
12,500	10 May 1986
9,000	1 Jul 1973
8,160	9 Jun 1974
7,000	16 Jun 1990
5,800	27 Aug 1975

JORDAN CREEK

There is no record of damaging floods occurring on Jordan Creek and no available experienced flood data. Until the 1970's, the watershed had little development; thus, flooding had been of little consequence. However, now that urbanization is occurring throughout the watershed, the threat of flooding is becoming a concern.

The city engineering staff for West Des Moines has stated that the development of the Jordan Creek watershed will include a master plan for stormwater management. The intent of the master plan will be to limit future urbanized runoff characteristic to existing conditions.

FLOW - FREQUENCY

RACCOON RIVER

Discharges for the Raccoon River at the project site were determined by using flow data from the stream gage at Van Meter.

Peak flows for various frequency floods were computed by methods outlined in the U.S. Water Resources Council Bulletin #17B (Reference B). This method uses a Pearson Type III distribution with a log transformation of the flood data. The log-Pearson Type III distribution is defined by three statistical parameters: the mean, the standard deviation, and the skew of the data. Computations were based on 74 years (1915-1988) of gaging station records with a generalized skew of 0.00 for this region and a station adopted skew of -0.30 being used in the analysis. No data on historic flood events outside the 74-year period of record are available; thus, no historic events were included in the analysis.

Discharges at Van Meter were adjusted to the West Des Moines study area on the basis of drainage area ratios raised exponentially to the area regression coefficients listed in Floods in Iowa: Technical Manual for Estimating Their Magnitude and Frequency (Reference C): $Q_{WDM} = Q_{VM} (DA_{WDM}/DA_{VM})$. The drainage area at Van Meter is 3,441 square miles and, at the study area, the drainage area of the Raccoon River has increased to 3,540 square miles. The x_t regression coefficients used for the 10-, 50-, 100-, 200-, and 500-year floods are 0.661, 0.647, 0.642, 0.640, and 0.636 respectively. This drainage area adjustment results in an approximate 2-percent increase in flow values. The Raccoon River flow frequency values are expected to remain stable with no future increases due to changes of land use or runoff characteristics in the basin.

Basic flow frequency data contained in the 1987 City of Des Moines Flood Insurance Study (FIS, Reference D) correspond to the Corps' results, with the exception that the study discharges include expected probability. Expected probability represents a statistical average of estimated future probabilities based on the existing period of record. The flow frequency data contained in the 1979 City of West Des Moines FIS (Reference E) is somewhat lower than current values due to the 1979 computations using USWRC Bulletin #17 methodology and a shorter period of record.

Peak flows from the multiple regression equations found in Method for Estimating the Magnitude and Frequency of Floods at Ungaged Sites on Unregulated Rural Streams in Iowa (Reference P) were computed to compare with the Bulletin #17B flow frequencies. A hydrologic region 4 was used for the Raccoon River. The results compare favorably when considering that regression equations do not account for the expected probability adjustment. Discharge frequency values are listed on table A-4 and are shown on plate A-7 for the adopted values at Van Meter.

TABLE A-4

Raccoon River
Discharge - Frequency Values

Location	Drainage Area, Square Miles	Discharge, cfs Q10	Q50	Q100	Q200	Q500
Raccoon River @ Van Meter	3,441	29,800	45,100	52,000	59,300	69,400
*Raccoon River @ 63rd Street	3,540	30,400	46,000	53,000	60,400	70,700
WDM FIS @ 63rd Street	3,540	29,200	41,100	45,700	---	55,900
DM FIS @ 63rd Street	3,540	28,900	42,900	49,100	---	64,000
Regression Eq. @ 63rd Street	3,540	29,900	39,600	46,000	---	---

* Adopted discharges for the project

WALNUT CREEK

Discharges for Walnut Creek were determined by several methods commonly used for computing flow-frequency relationships. These methods included the U.S. Water Resources Bulletin #17B log-Pearson Type III distribution of observed streamflow data, regional regression equations, and synthetic watershed modelling of the basin.

The Bulletin #17B analysis involved computing the peak flows for various frequency floods on Walnut Creek. Computations were based on 19 years (1972-1990) of gaging station records with a generalized skew coefficient of -0.10. The results yielded a standard deviation of 0.38 and a station computed skew of +0.71 in an area of normally zero to negative skews. A station adopted skew of +0.20 was computed and used in the final analysis. As such, the Bulletin #17B method yields results which are considered to trend high due to the hydrologic conditions which existed during the short period-of-record and to have a severe expected probability adjustment. The computed Bulletin #17B values are listed in Table A-6 and are shown on plate A-8.

A regional regression approach to the flow-frequency relationships of the Walnut Creek watershed involved an adopted procedure from past flood studies. At the request of the local communities in 1975, the Iowa Natural Resources Council (INRC), the USGS and the Corps of Engineers met to discuss the

differences between the discharges each agency was using for Walnut Creek and to try to establish a discharge relationship acceptable to all. From this meeting, it was concluded that flow frequency estimates for Walnut Creek which do not exceed USGS estimates (Reference C Regression Equations) by one standard error of estimate at a given frequency level would be adopted. This upward adjustment was made to account for the urban nature of the Walnut Creek watershed. Therefore, a frequency curve was computed using the sum of the original estimates of the USGS and standard error of estimate at respective frequency levels. This curve is shown on plate A-8. Table A-5 provides the supporting data for this frequency curve based on the Region I, Model 2 equations with a Walnut Creek main channel slope of 10.5 feet per mile. From this data, the INRC adopted a 100-year Regulatory Flood that ranges from 17,000 cfs at the mouth of Walnut Creek to 14,950 cfs above 86th Street in Clive. Discharges from this agreement also were used in the 1975 Corps of Engineers report Feasibility Study for Flood Damage Reduction and Related Purposes - Des Moines River Basin and the 1989 General Reevaluation Report. These reports outlined flood control measures for West Des Moines and Des Moines to provide protection from Raccoon River and Walnut Creek flooding. Additionally, the above discharges for Walnut Creek are officially recognized by the Federal Emergency Management Agency as the standard for future floodplain development and were used in the Des Moines, West Des Moines, Windsor Heights, and Clive Flood Insurance Studies. These discharges also were utilized in this study.

TABLE A-5

Walnut Creek Discharge Determination Data, Cfs

Return Period	USGS	Std. Error	USGS + Std. Error	Adopted
2-Year	2,175	40%	3,050	3,000
5-Year	4,150	29%	5,350	5,300
10-Year	5,730	26%	7,220	7,300
25-Year	7,990	31%	10,460	10,500
50-Year	9,850	37%	13,490	13,450
100-Year	11,800	44%	17,000	17,000

A subsequent 1978 report, Effects of Urban Development on the Flood-Flow Characteristics of the Walnut Creek Basin, Des Moines Metropolitan Area, Iowa (Reference Q) by the USGS concluded that for the 100-year flood to achieve a 17,000 cfs discharge, the Walnut Creek watershed would have to experience widespread urbanization. Thus, the INRC adopted discharges did verify in that study as an upper limit on which to manage future flood plain development.

Another USGS report, Flood Characteristics of Urban Watersheds in the United States, Water Supply Paper 2207 (Reference R),

outlines a methodology for urbanizing the regional regression equations found in Ref. P. This methodology applies basin development factors to the basic equations in determining an urbanized discharge-frequency relationship. A hydrologic region 2 was used; a region where landscape can vary from rugged to rolling topography. Runoff may be rapid , commonly causing threats of flash flooding. Expected urbanization of the Walnut Creek watershed would result in a basin development factor of 5. The results of this methodology compare well with the adopted values. The Water Supply Paper 2207 values are listed in table A-6.

TABLE A-6

Walnut Creek
Discharge - Frequency Values

Method	Discharge, cfs Q5	Q10	Q50	Q100	Q200	Q500
*Reg. Regression + 1 Std. Error	5,300	7,300	13,450	17,000	21,000	27,000
HEC-1	----	10,400	14,700	16,900	18,700	21,700
Bulletin #17B	4,320	6,510	13,700	18,100	23,300	31,800
with Exp. Prob.	4,490	7,050	17,100	24,300	34,400	54,400
USGS WSP 2207	6,800	8,900	14,000	17,200	----	----

* Adopted discharges for Walnut Creek

A synthetic watershed modelling approach was utilized as an additional means of comparison to the above modified regression values. A U.S. Army Corps of Engineers' HEC-1 - Flood Hydrographs (Reference F) model using Clark's synthetic unit hydrograph method was developed. The involved hydrologic parameters were verified by a calibration with the May 1986 flood of record. The historical and reconstituted hydrographs at 63rd Street for this flood are shown on plate A-9. The rainfall occurred in the 7-10 p.m. timeframe on May 9th. Also shown on plate A-9 is the elapsed times from the 8:30 p.m. center of rainfall to flood stage, 4.5 hours, and the 4:00 a.m. flood crest, 7.5 hours. Rainfall distribution data were limited from this flood; however; a good comparison of observed peak flows versus modelled peak flows was achieved based on aggregate rainfall depths which averaged approximately 4.5 inches in the upper Walnut Creek watershed. Hydrologic parameters used in the HEC-1 model reflect an agricultural fallow row crop condition indicative of when the May 1986 flood-of-record occurred. Runoff curve numbers (RCN) of 78-84 were used in computing the

rainfall/runoff relationships. RCN's in this range coincide with RCN's associated with urbanized conditions.

Point rainfall-depth-frequency data for the Walnut Creek watershed were determined from the National Weather Service Technical Paper No. 40 (Reference G). The discharge values from this method compare closely with the values from the modified regression equations. After analyzing the several flow-frequency methods, the continued use of the INRC regression flows was adopted as the design flows for Walnut Creek. These adopted flows were determined to be indicative of both the present and future flow-frequency relationships and maintains a consistent analysis with past studies and present flood plain management constraints. Discharge estimates from the various above methods are listed in table A-6, and the adopted frequency curve is shown on plate A-8.

JORDAN CREEK

The Jordan Creek watershed is similar in nature to the Walnut Creek watershed, adjacent to each other, and both are undergoing urbanization. West Des Moines city staff expect the watershed to be completely urbanized within the next ten years. For continuity in study methodology, the flow frequency methods used for Walnut Creek also were used for Jordan Creek. The method involves the regional regression equations contained in Reference C and adjusts these values upward by the standard error of estimate. From this curve (plate A-10), the adopted flow values are listed in table A-7.

Another USGS report, Water Supply Paper 2207, (Reference R) outlines a methodology for urbanizing the regression equations found in Reference P. A hydrologic region 2 was used with an expected urbanization development factor of 8. The results of this methodology are listed in table A-7 and are shown on plate A-10.

As another means of comparison, a synthetic watershed model approach was developed. An HEC-1 model using Clark's unit hydrograph method was used. No flood records exist for Jordan Creek; thus, no calibration of the rainfall/runoff model with observed events could be performed. Parameters used in the HEC-1 model include:

Time of Concentration = 2.3 hours
Drainage Area = 10.3 square miles
Attenuation Constant = 1.5 hours
Rainfall Losses: Loss Rate Based on RCN of 82

Point rainfall-depth-frequency data for the Jordan Creek watershed were obtained from Reference G. The discharge values

from this method compare closely with the values from the modified regression equations. Discharges for both are listed in table A-7, and the adopted frequency curve is shown on plate A-10. These flows represents urbanization of the watershed without a comprehensive storm management plan.

In 1980, the INRC published a report, Jordan Creek Flood Plain Study (Reference H) which determined the 10- and 100-year discharge estimates based on existing land-use conditions. Their values were computed using the U.S. Soil Conservation Service watershed model TR-20. This 100-year value is listed in table A-7. As expected, the INRC values are lower then current HEC-1 values due to using an existing 1980 mid-summer land-use condition.

The 1975 report, Reference A, computed the Jordan Creek flow frequency from a plot of mean annual flood vs. drainage area developed from seven central Iowa streams plus the computed standard deviation. These estimates were based on a drainage area of 12.8 square miles at Jordan Creek's mouth, whereas the above estimates were based on the 10.3 square-mile drainage area at the Chicago, Rock Island, and Pacific Railroad bridge project site. The previous 1975 flow estimates are listed in table A-7 and also reflect an allowance for the future urbanization of the watershed.

TABLE A-7

Jordan Creek
Discharge - Frequency Values

Method	Discharge, Cfs Q5	Q10	Q50	Q100	Q200	Q500
*Reg. Regression + 1 Std. Error	2,000	3,000	5,500	7,000	8,400	11,000
HEC-1	3,200	4,100	5,900	6,800	7,500	8,800
INRC	----	3,120	----	5,750	----	----
Mean Ann. Flood + Std. Dev.	1,900	2,850	6,000	8,000	10,400	14,000
USGS WSP 2207	2,500	3,200	5,100	6,150	----	----

* Adopted discharges for Jordan Creek

STANDARD PROJECT FLOOD

RACCOON RIVER

The Standard Project Flood (SPF) is a deterministic flood based on an analysis of regional rainfall characteristics. It is the flood that may be expected from the most severe combination of weather and runoff conditions that are considered reasonably characteristic of the drainage basin, excluding extremely rare conditions. The Raccoon River watershed above Van Meter was subdivided into three basins for which unit hydrographs were published in appendix A of the Master Reservoir Regulation Manual - Red Rock Reservoir, dated 1968 (Reference I). Using these unit hydrographs and the procedures outlined in EM 1110-2-1411, Standard Project Flood Determinations (Reference J) and appropriate rainfall losses, SPF hydrographs were then routed to Van Meter to yield the combined SPF hydrograph for the entire basin, as shown on plate A-11. The peak flow was then adjusted to the project location by the square root of the drainage area ratio. The resultant peak at 63rd Street is 143,000 cfs.

WALNUT CREEK

On Walnut Creek, a Standard Project Storm (SPS) was computed to determine the resultant SPF in Des Moines. The HEC-1 SPS routine was used to compute the SPF event in accordance with EM 1110-2-1411. The 24-hour, 200-square-mile index rainfall was determined to be 11.0 inches, with the average percent adjustment for area and duration of 123 percent. Storm computations indicated 13.6 inches of rain over a 96-hour period for the total SPS storm. Rainfall losses amounted to 2.7 inches, resulting in 10.9 inches of runoff. The SPF hydrograph showed a peak flow of 32,000 cfs and is shown on plate A-12.

JORDAN CREEK

Likewise, the HEC-1 SPS routine was used to compute the SPF event on Jordan Creek. The 24-hour, 200-square-mile index rainfall was determined to be 11.0 inches with the average percent adjustment for area and duration of 140 percent. Storm computations indicated 15.8 inches of rain over a 96-hour period for the total SPS storm. Rainfall losses amounted to 2.4 inches, resulting in 13.5 inches of runoff. The SPF hydrograph showed a peak flow of 13,200 cfs and is shown on plate A-12.

WATER SURFACE PROFILES

GENERAL

The hydraulic analysis for this study was conducted using the U.S. Army Corps of Engineers' HEC-2 - Water Surface Profiles computer program (Reference K). The program uses the backwater computational procedure generally known as the Standard Step Method to calculate the water surface profiles. The analysis for this project used the HEC-2 models developed in conjunction with the FIS's for Des Moines and West Des Moines. The initial channel roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment based on field observations. The HEC-2 models were then calibrated to experienced flood profiles on the Raccoon River and Walnut Creek. For the Raccoon River channel, an "n" values of 0.035 - 0.040 were used and an "n" value of 0.040 was arrived at on the Walnut Creek channel. Overbank "n" values of 0.080 - 0.100 were used on the Raccoon River floodplain and 0.080 - 0.100 on the Walnut Creek floodplain. Since no flood records exist for Jordan Creek, there is no basis for model calibration. Therefore, reasonable "n" values and conveyance characteristics were used based on previous modelling experience. An "n" value of 0.040 was used on the Jordan Creek channel, and overbank "n" values ranged from 0.070 to 0.100.

The hydraulic analyses of this study are based on the effects of unobstructed flow. The flood elevations, as shown on the profiles, are therefore valid only if the hydraulic structures and conditions remain essentially the same as ascertained during this study. Historical experience is that neither ice nor debris jamming on the streams in this reach has been a conducive element in flooding. However, the threat of such induced flooding does exist. Additionally, the cities of Des Moines and West Des Moines are participating in the National Flood Insurance Program. Thus, developmental encroachment into the floodways is not expected to occur.

RACCOON RIVER

Backwater computations on the Raccoon River were run to document existing condition profiles with the adopted flow values. The HEC-2 model included the Raccoon River reach from the mouth at the Des Moines River to Walnut Woods State Park. Most runs were initiated at Fleur Drive at River Mile 205.4 and extended to the upper end at River Mile 213.7. The project levee reach lies between River Miles 208.5 and 211.5 (Profile Stations 16500 and 31500). Starting water surface elevations were obtained from a rating curve developed from the FIS profile - flow data at Section 205.4. The flood of July 1986 was the primary

experienced flood that was used to calibrate the Raccoon River backwater model. Highwater marks were set by the cities of Des Moines and West Des Moines during the flood at various locations. This flood was estimated to be equivalent to a Corps of Engineers 25-year design flood event with a flowrate of 39,000 cfs. Additional verification of the existing condition Raccoon River profiles was provided by the June 1990 flood which was also estimated to be in the 40,000 cfs range at West Des Moines. The highwater marks in West Des Moines for this flood are shown on plate A-13. The computed existing condition flood profiles are also shown on plate A-13.

Water surface profiles for project conditions were computed by modifying the cross sections through the levee reach to reflect the alignment. All flood events were modelled such that the levee was not overtopped. This assumption is presented in order to show the maximum impacts of the levee alignment. The SPF flood will overtop the design levee grade, thus the tabulated increase in SPF profile elevation will be effectively reduced if such a flood were to occur. These profiles are shown on plate A-14.

The lower end of the proposed Raccoon River levee, Levee Station 101+00 to 120+00, lies landward of the FIS floodway. From Levee Station 78+00 to 101+00, the proposed alignment coincides with the established floodway. At the upper end, Levee Station 0+00 to 78+00, the alignment is again landward of the floodway. This ensures that the increases in flood levels due to the levee encroachment on the floodplain are less than the 1-foot allowance prescribed by the State of Iowa and the cities of Des Moines and West Des Moines floodplain management criteria as participating communities in the National Flood Insurance Program. Backwater computations indicate that the water surface elevations of the 10-, 50-, 100-, 200-, and 500-year and SPF floods would be increased by the amounts shown in table A-8. These maximum increases are observed in the river reach immediately upstream of Ponding Area C. The project condition modelling assumed that no additional flood plain obstructions would occur between the levee and the river. Also, the right overbank through the project reach would not be encroached upon as the ground is predominantly under public park use and the bluff line typically corresponds with the FIS floodway.

TABLE A-8

Impacts of Levee on Raccoon River Profiles

Flood Event (Year)	Increase in Profile Elevation (Feet)
10	0.0
50	0.1
100	0.1
200	0.1
500	0.1
SPF	0.9

WALNUT CREEK

Backwater computations also were run on Walnut Creek to document existing condition profiles with the adopted flow values. The HEC-2 model included the Walnut Creek reach from the mouth to upstream of the I-235 embankment. The starting water surface elevations for Walnut Creek were based on a mid-level Raccoon River receiving stream concurrent flood elevation. The mid-level elevation is based on a bankfull Raccoon River flow (2-year event) plus the incoming Walnut Creek flood flows. This methodology was utilized to avoid a possible overstating of the Walnut Creek flood damages on the lower reaches since, historically, flood peaks on each stream do not coincide. The 1973 pattern prevails when a typical storm system causes high water on each stream. In 1973, Walnut Creek peaked three days before the Raccoon River peak reached the project site.

During the May 10, 1986 Walnut Creek flood, the Raccoon River peaked seven days later at a flowrate slightly above a 2-year event. At the time of the Walnut Creek flooding, the Raccoon River was at normal seasonal streamflows. The June 1990 Walnut Creek and Raccoon River floods were caused by severe thunderstorms over the Walnut Creek and lower Raccoon River basins. A plot of the June 1990 Raccoon River and Walnut Creek stages is shown on plate A-17. At the time that Walnut Creek crested at 7,000 cfs on the 16th, the corresponding downstream Raccoon River flow at Fleur Drive in Des Moines was 24,000 cfs, a 5-year level. This flow can be broken down as 24,000 - 7,000 = 17,000 cfs. This is equivalent to the design Walnut Creek starting water surface assumption of a 2-year Raccoon River flow plus the incoming Walnut Creek flood peak flow.

Additionally, hydraulic characteristics of the confluence area are that the Walnut Creek channel enters the Raccoon River floodplain at a skewed angle with the mouth of Walnut Creek being located almost one mile downstream of the levee (see plate A-1). This results in the Raccoon River being the dominant controlling

flood source for design levee elevations on the lower reaches of the Walnut Creek levee. Final levee design profiles were based on Raccoon River flooding plus three feet of freeboard on the Walnut Creek levee reach up to North Valley Drive. From this point, Walnut Creek flood levels plus four feet of freeboard control. These hydraulic characteristics result in essentially no change in final design levee elevations even if the Walnut Creek profiling was started at the mouth based on equivalent coincidental Raccoon River flooding. The existing condition profiles for Walnut Creek are shown on plate A-15.

The flood of May 1986 was the primary experienced flood that was used to calibrate the Walnut Creek backwater model. Highwater marks were set by the cities of Des Moines and West Des Moines during the flood at various locations. This flood was equivalent to a 40-year design flood event with a flowrate of 12,500 cfs. Additional verification of the existing condition Walnut Creek profiles was provided by the June 1990 flood which was estimated to be in the 7,000 cfs range, or a 10-year flood event. The highwater marks for this flood are shown on plate A-15.

Flow Separation

The hydraulic characteristics of Walnut Creek at 63rd Street and Grand Avenue are complex in that a flow separation occurs at this location. At the 10-year flood level, floodwaters begin to overflow southerly thru the commercial area. These overflows then spread out in the flat residential areas of Des Moines and West Des Moines adjacent to 63rd Street. These overflows dissipate with no direct overland return flow to Walnut Creek. The hydraulics of this flow separation was modelled via HEC-2 with the frequency versus overflow listed in table A-9. The Walnut Creek starting flows were reduced by the listed amounts in the existing condition HEC-2 model. These overflows were then inserted at the valley section corresponding with the overflow section.

TABLE A-9

Walnut Creek Flow Separation

Flood Event (Year)	Overflow (Cfs)
2	0
5	0
10	450
25	950
50	1250
100	1500
200	1750
500	2050
SPF	2300

Project Conditions

Water surface profiles for project conditions were computed by modifying the cross sections through the levee reach to reflect the proposed Walnut Creek alignment. All flood events were modelled such that the levee was not overtopped. Project condition profiles indicate that the design levee grade is at the SPF design flood profile level. These profiles are shown on plate A-16. The first 600 feet of Walnut Creek levee, Levee Station 120+00 to 126+00, lies landward of the FIS floodway. From Levee Station 126+00 to 175+00, the alignment coincides with the FIS floodway. At Levee Station 175+00 to 192+00, the alignment consists of a floodwall running along the eastside of 63rd Street and around the Midland Brick warehouse. This reach of the alignment is inside of the FIS floodway for Walnut Creek with a resultant 1.3 foot increase in the 100-year flood profile. This is in excess of the 1-foot flood plain management regulations.

To mitigate this encroachment, bridge opening improvements at the Grand Avenue and 63rd Street bridges on Walnut Creek are included in the project. These bridge opening improvements are detailed on plate 53. These openings will need to be maintained by the cities of Des Moines and West Des Moines. Whenever the design opening cross-sections are decreased by 5% the cities will re-establish the design bridge opening.

From Levee Station 192+00 to the upstream tie-off, the levee alignment again coincides with the FIS floodway. This again ensures that the increases in the flood plain is compatible with the 1-foot floodway criteria.

Project condition HEC-2 backwater computations also included the design assumption that the adjacent Walnut Creek floodway fringe area was encroached upon. The resultant maximum water surface profile increases for the 10-, 50-, 100-, 200-, 500-year and SPF floods are shown in table A-10.

TABLE A-10

Impacts of Levee on Walnut Creek Profiles

Flood Event (Year)	Increase in Profile Elevation (Feet)
10	0.5
50	0.8
100	1.0
200	1.3
500	1.8
SPF	2.2

The channel Froude numbers were computed on Walnut Creek to assure flood flows were not in the 0.8 to 1.1 range where standing wares and slug flow can occur. The highest design flow Froude number was less than 0.6 with most locations in the 0.4 range. Thus, channel Froude numbers are in an acceptable range and are typical of subcritical flow tributary streams in the Rock Island District.

JORDAN CREEK

HEC-2 backwater computations were performed on Jordan Creek to determine the water surface flood profiles. Surveyed channel sections were combined with 1988 1-foot topography mapping to provide input into the HEC-2 model. The development, which has occurred in the Fuller Road area adjacent to Jordan Creek, was considered as an existing condition. The Jordan Creek flood profiles are shown on plate A-18. These profiles were computed for determining overflows into Interior Area 7, not for establishing design levee grades. The proposed Raccoon River levee tie-off will not impact on existing Jordan Creek flood characteristics.

Extending the upstream Raccoon River levee tie-off to provide 100-year plus freeboard flood protection for Jordan Creek was eliminated in the 1989 GRR report. To do so was found to be economically infeasible and operationally improbable with any type of closure structure located at Fuller Road. Short flood warning times of 1-2 hours make a timely closure unlikely. All of the buildings lying in the mapped Jordan Creek flood plain area have been constructed at above 100-year flood levels. Thus, supportable costs and residual damages are minimal.

Overflows of Jordan Creek into the protected area does not commence until Fuller Road overtops. Roadway overtopping begins between the 50- and 100-year flood levels based on uncontrolled urbanized flow frequencies. Overflows based on these conditions, 10 percent of flows exceeding the 50-year flow, would not cause damageable interior flooding at the design level under interior gravity flow conditions. The implementation of a comprehensive storm water management plan for the Jordan Creek watershed will reduce these overflows. The city of West Des Moines has indicated that a storm water management plan is being considered.

FLOW DURATION, STAGE DURATION AND RATING CURVES

All-year flow durations on the Raccoon River and Walnut Creek were obtained from the Van Meter and 63rd Street stream gages respectively. These flow duration curves along with stage

duration curves at the project location are shown on plates A-19 and A-20 . Stage versus flow rating curves are shown on these plates also.

FREEBOARD DETERMINATION

The effects of wind setup, ice jamming, allowance for debris blockage at bridges, water surface profile stability, variability of hydraulic roughness factors, inaccuracies and shifts in hydrology, levee settlement and overtopping superiority are considered as outlined in ETL 1110-2-299, Overtopping of Flood Control Levees and Floodwalls (Reference L) are factored into the design levee heights as freeboard above the design flood profiles. For this project, the design flood profiles include the water surface profile increase due to the levee encroachment onto the respective flood plain and the assumption of adjacent encroachment to the mapped flooding limit.

Raccoon River

The Raccoon River valley has flood plain widths of up to 3,000 feet thru the project reach, however limited sustained fetch lengths prevail as the river has a meandering stream and valley. Overbank tree and brush growth also limit the generation of significant waves due to wind setup. Therefore, an assumed wave height allowance of 0.5 feet is used. Bridge debris blockage and ice jamming has historically not been a factor in the major floods on the Raccoon River. However, the potential exists for debris and ice to impact on design flood levels. Thus, a 1.5 foot allowance is included. Levee settlement is taken into account in the construction design, however an allowance of 0.25 feet is included in the freeboard for excessive settlement.

Hydraulic contingencies account for a factor of 0.5 feet which includes increases due to water surface profile stability and roughness factor variability. Overall, the Raccoon River is a well established stream in dynamic equilibrium with the valley with an extended period-of-record. Major hydraulic shifts are not anticipated.

Hydraulic contingencies due to inaccuracies and shifts in the flow frequency relationship of the Raccoon River has a 0.25 foot allowance. The 74 year period-of-record results in a sound base for determining flows and significant changes in the 3,535 square mile basin is unlikely.

Volumes of Raccoon River floodwaters would be sufficient to reach equilibrium in the interior and exterior areas. If it is known that an imminent flood will overtop the project levee, it is recommended to allow the interior area to flood commencing at the downstream end by allowing initial overtopping to occur at the paved 63rd Street sandbag closure. This will ensure that a

catastrophic failure of the levee will not occur due to overtopping by allowing the interior areas to backfill with floodwaters having nondamaging velocities which could occur if the upstream end were to overtop first.

The multiple flood profiles are parallel thru the project reach for floods above the design flood profile. Thus, the overtopping flood level is consistent from the downstream end to the upstream end of the Raccoon River levee. Thus, in order to ensure upstream levee superiority concept, the levee freeboard will be increased by 1.0 feet at the upstream end with a transition to a 0.0 feet increase at 63rd Street. The 1.0 foot levee superiority allowance is consistent with past designs within the district for similar levee projects and has been an accepted standard. Table A-11, summarizes the freeboard allowance applied for each effect considered.

If floods in excess of the design 100-year flood were to occur, flooding up to the design 500-year flood level would be in the freeboard range of the design levee grade. Flooding in excess of the levee grade, including the SPF flood, would be of such duration as to cause widespread interior ponding. Swift currents throughout entire reaches are not likely given the flat topography of the leveed areas and the roadway and railroad embankments which divide the interior.

Table A-11

Raccoon River Freeboard Allowance

Effect	Freeboard, Feet
Wave Height	0.50
Bridge Debris / Ice Jamming	1.50
Excessive Settlement	0.25
Hydraulic Contingencies	0.50
Hydrologic Contingencies	0.25
Overtopping Superiority	0.00 - 1.00
TOTAL FREEBOARD	3 - 4 feet

Walnut Creek

The Walnut Creek valley has flood plain widths of less than 1,500 feet and no sustained fetch lengths. Overbank tree and brush growth also limit the generation of waves due to wind setup. Therefore, an assumed wave height allowance of only 0.25 feet is used. Bridge debris blockage and ice jamming has historically not been a factor in major floods on Walnut Creek. However, the potential exists; thus, a 1.5 foot allowance is included. Roadway overtopping will limit major stage increases due to bridge blockages. Levee settlement is taken into account in the

construction design, however an allowance of 0.25 feet is included for excessive settlement.

Hydraulic and hydrologic contingencies on Walnut Creek have a greater allowance than on the Raccoon River. An allowance of 1.0 feet was used for each factor. These increases are due to a shorter period-of-record, bridge improvements, maintenance uncertainties, a greater instability of stream dynamics and urbanization unknowns.

Initial re-evaluation formulation of the Walnut Creek levee included one foot of upstream levee superiority with total freeboard ranging from three feet at the downstream end at Valley Drive to four feet at the upstream end. Final planning with CENCD input decided on providing a uniform overtopping profile on the tributary tie-off levee. Thus, four feet of total freeboard was provided on the Walnut Creek reach. This formulation change facilitated containing the design Walnut Creek SPF flood within the freeboard zone. The topography characteristics of the interior protected area were conducive to this decision. Table A-12 summarizes the freeboard allowance applied for each effect considered.

The impacts of Walnut Creek levee overtopping is dependent on the depth and duration of overtopping. A brief low level overtopping of the levee would not cause catastrophic interior flooding. The topography of the protected areas of the Walnut Creek flood plain does not have steep upstream to downstream gradients. Typically, the protected area is a flat widespread area common to the Raccoon River flood plain. Initial overflows would cause shallow flooding in the immediate overflow area with continued overflows spreading out thru the interior. Sustained overflows would continue to accumulate in the interior. However, it is highly unlikely that levee overtopping would reach an equilibrium of exterior stream stages and interior ponded overflow levels. A failure of the levee would need to occur in order to achieve this worst case scenario. If overtopping were to occur, the initial overtopping location would likely be the floodwall reaches.

Of note is the characteristic that the Raccoon River design flood level plus three feet of freeboard will govern up Walnut Creek to Valley Drive, at which point Walnut Creek flood levels plus four feet of freeboard will control.

Table A-12

Walnut Creek Freeboard Allowance

Effect	Freeboard, Feet
Wave Height	0.25
Bridge Debris / Ice Jamming	1.50
Excessive Settlement	0.25
Hydraulic Contingencies	1.00
Hydrologic Contingencies	1.00
TOTAL FREEBOARD	4 feet

LEVEE PROJECT OPERATION

The operation of the overall flood protection project can be subdivided several ways; Raccoon River vs. Walnut Creek, exterior vs. interior closures, and Des Moines vs. West Des Moines. This section will discuss exterior flooding from each of the two streams and outline functional local responsibilities of operation for roadway/railroad closures. A later section of this appendix will discuss functional operation of the interior flood control facilities.

Raccoon River:

As discussed in Addendum A - Flood Warning and Flood Response, the flood fighting procedures to guard against Raccoon River flooding have been institutionalized for each city. The advance warning available provides the locals with time to perform beneficial flood damage reduction activities in the past. The capital improvements provided by the flood protection project will provide the comprehensive solution they have long desired. The operation of the project will be included in each city's updated flood emergency plans. The Raccoon River levee operation includes one road closure on 63rd Street, two railroad closures on the Chicago-Northwestern Railroad and one combination access road/spur railroad closure. The pertinent details of these closures are listed on table A-13.

Closures located in the freeboard zone are sandbag closures. Closures located below the design flood level are swing gate structures. This will ensure ample time in which to make all closures. The locals will be placed on an initial alert for monitoring of Raccoon River stream stages whenever the NWS issues a Flood Warning Bulletin on the Raccoon River basin. A secondary alert level, typically coming 1-2 days later if flooding actually develops in the basin, will correspond to West Des Moines' present "green" alert. This will occur when the stage at Van

Meter reaches 13.0 feet (expectant 31.0 at West Des Moines). At this alert level, the river is still within its banks. However, it should be monitored for possible ice jamming and debris blockages. Some interior drainage facilities may be closed at this level. No roadway/railroad closures are necessary at this level.

The mobilization for roadway/railroad closures will occur when a present "yellow" alert level is reached; 20 to 22 feet at Van Meter (expectant 38 to 40 feet at West Des Moines). If the Raccoon River exceeds 20.5 feet at Van Meter, the city of Des Moines should mobilize to prepare to make closure of the downstream Chicago-Northwestern Railroad at Station 103 + 57. The railroad will be notified thru established procedures and closure should be made when the river reaches within two feet of the closure sill. Closure time on this swing gate is 1.5 hours. Rates of rise on the Raccoon River are typically four inches per hour for floods of this magnitude.

The city of West Des Moines should mobilize to prepare to make closure of the swing gate at Station 39+33 when the Raccoon River exceeds 37.0 feet at Van Meter. Actual closure should be made when the river reaches within two feet of the sill elevation. This is the combination access road/spur track closure.

The closure at 63rd Street is needed at elevation 43.5 in West Des Moines. This elevation for closure is based on the proposed Iowa Department of Transportation roadway elevations as part of their concurrent road improvement project. This elevation of 43.5 relates to a stage of 25.5 at Van Meter. West Des Moines will be the lead city in making this sandbag closure with Des Moines providing backup support. This closure should be made when the Raccoon River reaches within two feet of the sill elevation.

The final Raccoon River closure is a 1.0 foot high railroad freeboard closure at Station 9+65 at the upstream end. The mobilization for this sandbag closure should be made by West Des Moines when the stage at Van Meter exceeds 27.2 feet with actual closure occurring when stages reach within two feet of the sill. This will be an infrequent level of closure. All of the above alert, mobilization and closure levels are listed on table A-13. Available warning times and times to closure are also listed.

Walnut Creek:

Roadway/railroad levee closure operations on the Walnut Creek portion of the project were formulated and designed with the limited advance warning time as an overriding parameter. Flood warning and response for Walnut Creek is addressed in Addendum A. Closures are kept to the minimum number necessary. All closures are swing or slide gates which can be rapidly closed. Closure times on the swing and slide gates were established at one hour

each for single railroad track and two-lane road closures; and 1.5 hours each for double railroad track and any four-lane or more road closures. The closure times include the time to mobilize at the site, place required materials and make the actual closure. Based on initial emergency coordination and personnel mobilization occurring in the flood warning system alert phase, city staff felt these closure times were conservative. No sandbag or panel closures are recommended on Walnut Creek.

Five roadway/railroad closures are located on the Walnut Creek portion of the levee, two road closures at Grand Avenue and 63rd Street, two railroad closures on the Norfolk Southern Railroad, and one service road closure. A sixth closure located at North Valley Drive is not needed as the city of Des Moines ramped this roadway when the bridge was replaced in the early 1980's. The pertinent details of these closures are listed on table A-13.

The cities of Des Moines and West Des Moines will be placed on alert whenever the NWS issues a Flood Warning Bulletin for the Walnut Creek basin or when an alarm warning parameter built into the ALERT system is reached as outlined in Addendum A. The locals will monitor the ALERT system and NWS forecasts on a regular basis to keep abreast of any developing flood situation. Additionally, initial mobilization of emergency responses can be coordinated in this alert phase.

The NWS River Forecast Center (RFC) in St. Paul, Minnesota, developed hydrologic watershed models and flood advisory tables that provide peak streamflow and time-to-peak forecasts based on antecedent moisture conditions and observed rainfall depths. These efforts, done as a part of the development of the ALERT system, have been coordinated with the Rock Island District.

CENCR HEC-1 modelling of the Walnut Creek watershed has verified the RFC methods and results. Plate A-9 shows the timing of rainfall to flood stage and flood crest for the May 1986 event at 63rd Street. Plate A-12 indicates a conceptual check on the warning time available on a stream. This warning time indication is determined by the rate of rise time period in the rising limb of the SPF hydrograph from the flood stage flow to the 100-year flow. This time is indicated as six hours. The above HEC-1 modelling results check with the NWS Flood Advisory Table warning times listed on Attachment C of Addendum A for the Walnut Creek location in West Des Moines/Des Moines. The additional HEC-1 modelling done as a comparison for the Walnut Creek flow-frequency determination also is compatible with the NWS RFC warning times.

Upon observation thru the ALERT system that Walnut Creek basin rainfalls are exceeding that day's NWS Flood Advisory Table basin index rainfall to cause flood stage or flood stage is reached at any of the three stream gages, official mobilization should commence. Interior drainage facilities will need initial action.

These will be addressed later in this appendix. The basin index rainfall method is outlined in Addendum A on page AA-5. This value can range from 1.0 inches during wet antecedent moisture conditions to 5.0 inches during drought periods.

The decision to make closure at each of the above locations should be made whenever the Walnut Creek stage is forecasted to be within two feet of the sill elevation at each closure. This will add a safety factor to all closure decision points in the event actual stages are higher than the forecasted stages. Thus, the initial roadway/railroad closures should be made at a forecasted stage of 16.0 feet. This information is tabulated on table A-13. Since October 1971, a stage of 16.0 feet has been exceeded on six occasions.

The first two roadway/railroad closures will be the Norfolk Southern Railroad swing gate by 63rd Street at Station 189+46 and the Wheeler Lumber service road swing gate at Station 218+00. Des Moines will have primary responsibility for the railroad closure and West Des Moines will be the lead on the Wheeler Lumber closure. Each city will serve as a backup to the other on all levee and gatewell closures. Both of these closures have sill elevations equivalent to a flood stage of 18.0 feet. These closures can be made in one hour each with the advance warning time of four hours available.

Subsequent closure sill elevations on the Grand Avenue slide gate at Station 184+61 and the 63rd Street swing gate at Station 192+70 are overtopped when a flood stage of 19.5 feet is exceeded. Des Moines will be responsible for the Grand Avenue closure and West Des Moines will handle the 63rd Street closure. These closures can be made in 1.5 hours each with an advance warning time of five hours available.

The final railroad swing gate closure at Station 219+67 will need to have been made by West Des Moines when a flood stage of 20.0 feet is reached. This closure can be made in one hour with an advance warning time of five hours available.

During flood response operations, personnel from both city's various departments will perform pre-established duties as specified in their respective flood emergency plans. These duties are outlined in Addendum A. Historically, Des Moines' and West Des Moines' responses to flood emergencies have been well coordinated, provided advance warning time has been available.

Effects of Nonclosure of Road and Railroad Closures

Failure to make closure at any of the closure locations would have varying effects on the protected areas. The effects would depend on the depth and duration of exterior floodwaters which encroach on the open closure structure. The lower in relative elevation the closure sill is, the more likely that a flood is to

overtop the closure sill. On the Raccoon River, the lowest closure sill is located at the 20-year flood level and is three feet below the design flood stage. The remaining three closures are higher, with two being located in the freeboard zone. Failure to close any of these four Raccoon River closures is highly unlikely given the advance warning time available. However, if closure is not made, significant interior flooding could occur with a sustained nonclosure. Emergency service personnel would flood-fight any nonclosure, thus limiting the amount of inflows.

The formulation and design of the Walnut Creek levee gate closures is consistent with the prevailing advance warning times available, and the operation of the project features is within the resources of each city. The Walnut Creek lowest closure is located at the 10-year flood level, which is 3.5 feet below the design flood level. If closure is not made at one of these two closures located at the 10-year flood level during a 100-year design flood, the resultant inflows to the interior would be approximately equivalent to an existing condition 10-year flood event. If neither of these two closures were made, the interior would experience approximately a 25-year existing condition flood. Failure to close three or more of the five closures would result in interior flooding equivalent to existing 100-year conditions. These scenarios are based on a computation of weir inflows with a coefficient of 2.7 at each closure sill. Inflows were then compared to backwater modelling of the Walnut Creek flow separations which presently occur in this reach where the proposed closures are located. Flooding of the interior would not be greater than existing conditions under any nonclosure scenario. Velocities of inflows would be less than 5 feet/second. As with Raccoon River flooding, any sustained nonclosure location would be flood-fought by emergency service personnel to rectify the problem before catastrophic damages would likely occur.

TABLE A-13

SUMMARY OF ROAD AND RAILROAD CLOSURE
WEST DES MOINES-DES MOINES, IOWA

					ALERT				MOBILIZATION				SILL OVERTOPPING							
STATION	LOCATION	AFFECTED BY	CLOSURE DIM. (HxW,FT)	TYPE	STAGE GAGE (FT) *1	STAGE CITY (FT) *2	Q (CFS)	FREQ (YR)	STAGE GAGE (FT) *1	STAGE CITY (FT) *2	Q (CFS)	FREQ (YR)	STAGE GAGE (FT) *1	STAGE CITY (FT) *3	Q (CFS)	FREQ (YR)	100 YEAR STAGE *3	SPF STAGE *3	AVAIL. TIME (HR)	SAFETY FACTOR
9+65	C-RR&P RR	Raccoon	2x30	Sandbag	13	31	8500	1.25	24.2	42.2	50,000	100	26.2	46.0	65,000	300	44.0	53.4	15+	7.5+
39+33	Lincoln Rd	Raccoon	7x35	Swing Gate	13	31	8500	1.25	19.2	37.2	23,000	5	21.0	40	35,000	20	43.0	52.8	15+	10+
89+76	63rd St.	Raccoon	1.7x50	Sandbag	13	31	8500	1.25	23.5	41.5	45,000	50	25.5	43.5	60,000	200	42.2	50.7	15+	5+
103+57	C & NW RR	Raccoon	4.3x60	Swing Gate	13	31	8500	1.25	20.0	38.0	26,000	8	22.0	39.9	40,000	33	41.2	48.5	15+	10+
184+61	Grand Ave.	Walnut	6.3x65	Slide Gate	Nat. Weather Serv.				17.5	44.7	6,500 Forecasted	8	19.5	44.3	10,000	20	46.6	49.7	5	3.3
189+46	N-S RR	Walnut	7.6x20	Swing Gate	Flood Warning				16	43.2	5,000 Forecasted	4	18	44.3	7,300	10	47.9	51.2	4	4
192+71	63rd St	Walnut	5.9x60	Swing Gate	Bulletin or				17.5	44.7	6,600 Forecasted	8	19.5	46.7	10,000	20	48.6	52.2	5	3.3
218+00	Wheeler	Walnut	7.3x30	Swing Gate	ALERT System				16	43.2	5,000 Forecasted	4	18	47.2	7,300	10	50.5	54.5	4	4
219+67	N-S RR	Walnut	5.5x40	Swing Gate	Alarm Warning				18	45.2	7,300	10	20	49.0	11,500	25	50.5	54.5	5	3.3

*1 Stage @ Van Meter Gage, 0.0 = 841.2 NGVD
Stage @ 63rd Street Gage, 0.0 = 801.0 NGVD

*2 Stage @ 63rd Street, Racoon/Walnut, 0.0 = 773.8 NGVD
Stage @ Site Location, 0.0 = 773.8 NGVD

SECTION 3 - INTERIOR FLOODING

GENERAL

The interior drainage area resulting from the proposed levee construction totals 2,430 acres (3.8 square miles) of residential, commercial, industrial, and public use development as shown on plate A-21. The interior area is essentially fully developed with only a few remaining parcels of undeveloped land. In general, the interior area slopes southeasterly toward the Raccoon River and Walnut Creek channels.

DESCRIPTION OF INTERIOR AREAS

The 3.8 square miles of interior area was divided into seven sub-areas which reflect unique drainage and outlet characteristics. An 18-acre area, Area 1, is located along the upper end of the Walnut Creek levee. Area 1 includes the Wheeler and Beisser Lumber Company properties and Hoak Drive drainage. Area 2 consists of the 160-acre drainage in the Grand Avenue and Ashworth Road area of West Des Moines. Several storm sewer outlets are located in this area which outlet under 63rd Street to Walnut Creek. Area 3 is 150 acres of mainly residential property lying in both Des Moines and West Des Moines and outlets to Walnut Creek. Area 4 is 30 acres of residential and industrial property lying mostly in Des Moines and outlets to the Raccoon River. Area 5, 885 acres, consists of the downtown Valley Junction area of West Des Moines and the residential and commercial property surrounding the downtown area. Area 6 is the Fairmeadows Creek watershed, having a drainage area of 1,125 acres. Area 7 is 55 acres of local drainage at the upstream end of the Raccoon River levee reach which outlets into the lower Jordan Creek system. Specific design analysis on these areas will be addressed later.

INTERIOR FLOODING METHODOLOGY

The interior drainage watersheds were modelled with the HEC-1 Flood Hydrograph program. The HEC-1 model includes drainage areas, times of concentration, Clark's unit hydrograph method, and rainfall-runoff relationships in arriving at resultant runoff hydrographs for given frequency storms.

The times of concentration (Tc) for the interior areas were determined using the composite travel times method which is applicable to urban areas. The travel times method is based on watershed length, slope, and surface conditions, and uses the SCS Technical Release No. 55, Urban Hydrology for Small Watersheds

(Reference M). Travel velocities were based on surface flow conditions.

The Clark's unit hydrographs for each area and subareas are based on the basin's drainage area, time of concentration, and Clark's basin attenuation constant, R. R can be difficult to estimate in small, urban, ungaged watersheds. However, past experience with Rock Island District watersheds indicates that a reasonable range of R is between 0.47 and 1.00 times Tc. For the interior areas, an R value from 0.50 to 1.00 times Tc was used depending on the watershed's characteristics. Land use in the interior watersheds is essentially fully urbanized; thus, future hydrologic conditions will remain the same as base project conditions. The hydrologic values for the interior areas are listed in table A-14.

TABLE A-14

Hydrologic Values for Interior Areas

Area #	Drainage Area, Ac.	Tc, Min.	R, Min.	RCN	Slopes, %
1	18	30	15	87	0-2
2	160	42	28	79	2-5
3	150	45	45	80	0-2
4	30	9	9	82	0-2
5 *	885	90	90	76	0-5
6 *	1125	66	45	75	2-9
7	55	38	38	88	0-2

* Composite for watershed subareas

Point rainfall-depth-duration-frequency data for the Des Moines region were obtained from Reference G. The design rainfall data values are listed in table A-15. Rainfall losses for infiltration were computed by the SCS Runoff Curve Number (RCN) method. The RCN is determined based on the watershed's hydrologic soil type, land use, and antecedent moisture conditions. The hydrologic soil types consist of the type B classification. The initial rainfall loss (Ia) is computed by the following:

$$S = \frac{1000}{RCN} - 10$$

$$Ia = 0.2(S) \text{ inches.}$$

Runoff hydrographs for the interior were derived by the convolution of the unit hydrographs and rainfall/runoff values via HEC-1. Runoff hydrographs were computed for storms ranging from 2-year to the 500-year event.

Runoff volumes from the interior drainage areas tributary to the Raccoon River also were modelled by a second method involving the Rock Island District computer program AGDRAN (Reference N). The AGDRAN program computes the interior runoff via a volumetric computation based on historical rainfall, monthly runoff factors, daily distribution percentages, and drainage area. The analysis is a period-of-record type analysis. Also included are data on the concurrent exterior river stage and seepage factors. For this study, an AGDRAN analysis using discrete flood events was used to model blocked gravity conditions. The time period modelled was from 1947 to 1989 using a combination of historical stages and stream gage records on the Raccoon River.

TABLE A-15

Rainfall Depth - Duration - Frequency

Frequency	Duration, Hours					
	1	2	3	6	12	24
	Depth, Inches					
1-Year	1.3	1.6	1.7	2.0	2.3	2.6
2-Year	1.6	2.0	2.1	2.4	2.8	3.2
5-Year	2.0	2.5	2.6	3.1	3.5	4.0
10-Year	2.3	2.9	3.0	3.6	4.1	4.7
25-Year	2.7	3.3	3.5	4.1	4.7	6.3
50-Year	3.0	3.7	3.9	4.6	5.3	6.0
100-Year	3.3	4.1	4.3	5.1	5.9	6.6
200-Year	3.6	4.4	4.7	5.5	6.3	7.2
500-Year	4.0	5.0	5.3	6.2	7.1	8.1

INTERIOR FLOOD ANALYSIS AND DESIGN

The occurrence of fluctuating water levels, both exterior and interior to the line-of-protection is the aspect that makes interior flood control analysis unique (see EM 1110-2-1413 Hydrologic Analysis of Interior Areas, Reference O). The interrelationships between interior flooding versus exterior Raccoon River or Walnut Creek flooding have different characteristics. Walnut Creek is a small watershed which is prone to flash flooding with the same storm systems causing concurrent interior runoff at the project site. The Raccoon River is a large river basin system in Iowa where floods in the lower basin typically take days to develop; thus interior runoff on the small interior areas has typically been conveyed to the river prior to the impending flood. These unique characteristics, along with extended hydrologic data being available on the Raccoon River, dictated that two different interior flood control methodologies needed to be used for the

project. The high degree of coincidence and correlation of Walnut Creek interior and exterior water levels (Areas 1, 2 and 3) dictated an interior flood analysis and design using a hypothetical frequency methodology. The interior flood analyses and design for the Raccoon River tributary areas (Areas 4, 5, 6 and 7) were done using the multiple event method as described in EM 1110-2-1413.

For Walnut Creek tributary interior areas, the hypothetical frequency method used coincidental frequencies of interior and exterior events; i.e. the same rainfall storm occurs on both areas. Operationally, it would be unreasonable to assume that all the interior runoff would be trapped within the line-of-protection. Thus, initial infiltration losses were increased one inch to approximate the effect of city emergency crews releasing one inch of interior storm water runoff before closure of the gravity outlets are made. During real-time flood fighting, the gravity outlets would be monitored and left open as long as storm water was vigorously exiting the interior area.

The multiple discrete events analysis is based on the development of interior stage-frequency functions for areas affected by coincident (interior and exterior) flooding. The method generates a composite stage-frequency function from analysis of two conditions. The first involves analysis of selected high stage exterior flood events of historic record that effect interior flooding. The second condition involves analyses of low exterior stages associated with an interior flood analysis generated by hypothetical frequency storm events. The result is a stage-frequency function for each of the two conditions. They are then combined into a composite function by the application of the joint probability theorem.

Interior ponding frequency curves are developed for each interior area of the levee project. A total of seven areas were analyzed, three along Walnut Creek and four along the Raccoon River. The composite curves represent the residual interior ponding with the proposed gravity outlets, ponding areas, pump stations, and flood control levee in association with the existing drainage facilities. The reductions in residual damages, based on the with-pumping curves, represent the supportable cost of pumping for each area. The GRR study found only Areas 2 and 5 to have supportable costs to justify pumping facilities. The recommended pump station sizes are based on an economic optimization of the cost of providing pumping versus the associated interior damage reduction. Pertinent information on each of the interior drainage outlets is listed in table A-40 on page A-50. The identified residual one percent interior ponding associated with the flood control project is shown on plate A-37.

Area 1

This 18-acre drainage area is located along Hoak Drive at the upstream end of the Walnut Creek levee. The area includes the Wheeler and Beisser Lumber Companies, Midland Brick, and Hoak Drive right-of-way. The stage versus damage data for Area 1 are listed in table A-16. The area presently drains via overland flow to Hoak Drive, at which point it passes thru a small road culvert or directly over the road to Walnut Creek. At Station 202+70, a gravity drain with a gatewell closure will be constructed at the levee intercept. Excess runoff will be temporarily ponded in the existing Hoak Drive right-of-way. The stage versus storage curve for this area is shown on plate A-22.

TABLE A-16

Area 1 - Stage vs. Damage

Stage, City	Stage, NGVD	Damages, $
43.2	817.0	0
44.2	818.0	55,000
45.2	819.0	112,000
46.2	820.0	187,000

The interior flood control analysis for Area 1 involved computing the HEC-1 hypothetical frequency storm events and routing the runoff hydrographs through the outlet under design conditions using a 24-inch RCP. A 24-inch gatewell outlet is the smallest recommended functional size to use for discharging storm drainage. The interior ponding stage versus frequency curves are shown on plate A-23 and pertinent ponding stages are listed in table A-17. Also listed on table A-17 is the interior SPF gravity flow ponding stage. Interior runoff is ponded on Hoak Drive, 41.2 City datum, for events exceeding a 2-year frequency. The residual 100-year interior ponding elevation of 42.7 City datum results in no adjacent structural property damages. Thus, pumping facilities are neither feasible or needed at this location. The 24-inch gravity outlet represents the minimum facility to provide site drainage for this 18-acre area.

TABLE A-17

Area 1 - Interior Ponding Stages

Flood Event	Stage, City	Stage, NGVD
2-Year	41.2	815.0
10-Year	42.1	815.9
100-Year	42.7	816.5
SPF	43.1	816.9

Area 2

Area 2 is a 160-acre watershed tributary to Walnut Creek consisting of upland residential and commercial development and the floodplain area having extensive commercial development. The area is serviced by one 24-inch RCP, one 30-inch RCP, and three 36-inch RCP storm sewers. There exists a low area in the business district along Grand Avenue which experiences ponded water in the streets and parking lots during heavy rainfalls. The recommended interior flood control design includes abandoning the five existing outlets and connecting the storm sewers together with an interceptor sewer along the westside of 63rd Street. A gravity outlet and pump station will be placed at Station 187+85 on the eastside of 63rd Street. The layout for this plan is shown on plate 19. Excess runoff will be temporarily ponded in the existing low-lying streets and parking lots. The stage versus storage curve for this existing ponding is shown on plate A-24.

The existing storm drainage facilities that must be relocated dictate the minimum facility concept for the interception and discharge of gravity flows. This includes intercepting the 36-inch RCP Ashworth Road storm sewer with a 36-inch RCP on the north. On the southside; the 30- and 18-inch storm sewers will be intercepted by a 36-inch running northward to Grand Avenue at which point a 24-inch RCP will be picked up. A 48-inch RCP will run under Grand Avenue to the 36-inch RCP on the northside. From this point, a 54-inch RCP will lead to a junction storm box where the rerouted Ashworth storm sewer, the 54-inch storm sewer, and the existing 36-inch Valhigh storm sewer will be combined. A five foot by seven foot RCB culvert under 63rd Street will discharge through a gatewell to Walnut Creek. A layout of the plan is shown on plates 19 and A-38.

The interceptor storm sewers were sized based on the rated capacities determined by a city of West Des Moines contract study titled Storm Drainage Study 1975 (Reference V). This study presented the results of engineering studies and analyses of existing storm water problems made in the development of a long range storm drainage facilities plan for the city of West Des Moines. The study report included existing storm sewer capacities within the project area. These capacities are listed in table A-18 along with other pertinent data. These listed capacities were used to size the interceptor sewers leading to the combined gravity outlet located at Station 187+85. The storm sewer intercept sizes were determined from Figure 4 of Concrete Pipe Design Manual prepared by the American Concrete Pipe Association (Reference W). Figure 4 is reproduced as plate A-36. Pertinent data concerning the interceptor storm sewers are listed in table A-19.

TABLE A-18

Area 2 - Storm Sewer Capacities

Name	Service Area, Acres	Size	Type	Capacity, Cfs
Ashworth	66	36"	RCP	34
Valhigh	22	36"	RCP	60
Grand N	51	36"	RCP	40
Grand S	14	24"	RCP	21
63rd St. 1	2	18"	RCP	6
63rd St. 2	5	30"	RCP	30

TABLE A-19

Area 2 - Interceptor Storm Sewers

Name	Design Capacity, Cfs	Size	Type	Slope, %
Ashworth	34	36"	RCP	0.2
Valhigh	No Interceptor Storm Sewer Required			
Grand N	91	54"	RCP	0.3+
Grand S	51	48"	RCP	0.2
63rd St.	36	36"	RCP	0.3

The gatewell structure will include a pump station to evacuate excess interior runoff during Walnut Creek flood events. Pump station economic justification and optimization is based on the amount of residual interior damages which exist with the levee in-place and the benefits obtained by reducing these damages versus the associated costs of providing pumping. A seepage allowance was not used in the analysis due to the impervious nature of the interior ponding areas and the limited time Walnut Creek is at flood stage. The stage versus damage data for Area 2 are listed in table A-20.

TABLE A-20

Area 2 - Stage vs. Damage

Stage, City	Stage, NGVD	Damages, $
40.2	814.0	0
41.2	815.0	65,000
42.2	816.0	154,000
43.2	817.0	426,000
44.2	818.0	1,318,000

The interior flood control analysis involved computing the hypothetical frequency storm events and routing these storms

through the existing relocated facilities and several design alternatives involving pumping capability. Pumping capacities of 5,000, 10,000, 20,000 and 35,000 gpm were evaluated. These routings yielded the interior ponding versus frequency curves shown on plate A-25.

The incremental costs of adding pumping to the gravity outlet gatewell structure are listed in table A-21. These costs are based on a 100-year design period with an 8-7/8 percent interest rate. Annualized replacement, energy, and maintenance costs are also factored in to the total cost.

TABLE A-21

Area 2 - Pump Size vs. Cost

Size, Gpm	First Cost, $	Annualized Cost, $ First	Replace	Energy	Maint.	Total
5,000	50,000	4,400	200	400	3,000	8,000
10,000	70,400	6,200	300	400	3,000	9,900
20,000	97,700	8,700	400	400	3,000	12,500
35,000	156,200	13,900	700	400	4,500	19,500

The economic damage-benefit-cost data for the benefits derived from providing pumping versus the cost of providing pumping are summarized in table A-22.

TABLE A-22

Area 2 - Pumping Station Benefits vs. Cost

Size, Gpm	Annual Benefits, $	Annual Cost, $	Net Benefits, $	BCR	Residual Damages, $
No Pump	- 0 -	- 0 -	- 0 -	-	71,900
5,000	30,800	8,000	22,800	3.85	41,100
10,000	49,100	9,900	39,200	4.96	22,800
20,000	56,800	12,500	44,300	4.54	15,100
35,000	63,600	19,500	44,100	3.26	8,300

As indicated in table A-22, the optimized pump station size is the 20,000 gpm pumping rate with a net benefit of $44,300. Thus, the 20,000 gpm pumping rate is the selected size pump station. A residual interior damage of $15,100 is associated with this rate of pumping. This design results in a residual 100-year interior flood elevation of 42.4 City datum (816.2 NGVD). Pertinent interior ponding stages for the selected 20,000 gpm pump station are listed in table A-23. Also listed in table A-23 is the interior SPF gravity flow ponding stage.

TABLE A-23

Area 2 - Interior Ponding Stages

Flood Event	Stage, City	Stage, NGVD
2-Year	39.0	812.8
10-Year	40.9	8 4.7
100-Year	42.4	816.2
SPF	43.8	817.6

Area 3

Area 3 is a 150-acre watershed tributary to Walnut Creek. The area is primarily residential and has little topographic relief. The stage versus damage data for Area 3 are listed in table A-24. Interior runoff is presently discharged to Walnut Creek via a variety of storm sewers and culverts. At Station 170+85, a 24-inch RCP storm sewer which serves the Legion Park area of West Des Moines will be intercepted with a 42-inch RCP. The existing outlet will be plugged and abandoned. A 30-inch RCP at station 170+67 will also be intercepted with the new 42-inch pipe. This 30-inch storm provides drainage for the 63rd Street roadway. The new intercept sewer will run along the landside of the levee to Station 147+00. The existing 18-inch storm drain at this location will be abandoned with the new drainage flowing into the intercept sewer. The intercept sewer will continue along the levee and pass under the Valley Drive embankment to the outlet channel for Ponding Area D. A layout of the plan is shown on plates 16, 17 and A-39.

TABLE A-24

Area 3 - Stage vs. Damage

Stage, City	Stage, NGVD	Damages, $
32.2	806.0	0
33.2	807.0	3,000
34.2	808.0	12,000
35.2	809.0	58,000

The interceptor storm sewer was sized based again on the rated capacities in the Storm Drainage Study. These capacities are listed in table A-25 along with other pertinent data. The subsequent storm sewer interceptor size was determined from Figure 4 on plate A-36. Pertinent data concerning the interceptor storm sewer are listed in table A-26.

TABLE A-25

Area 3 - Storm Sewer Capacities

Name	Service Area, Acres	Size	Type	Capacity, Cfs
Vine	32	24"	RCP	15
1st St.	25	30"	RCP	18

TABLE A-26

Area 3 - Interceptor Storm Sewers

Name	Design Capacity, Cfs	Size	Type	Slope, %
Area 3	33	42"	RCP	0.14

Ponding Area D is a 10-arce excavated site which will double as a on-site borrow area. The entire ponding area site is already under city of Des Moines ownership. The proposed stage versus storage for this ponding area is shown on plate A-26. The outlet is sized at a 48-inch RCP gravity outlet with a gatewell closure. Site drainage along the levee will be graded so as to drain toward the ponding area and each manhole cover along the intercept sewer should be graded for site drainage relief. Site grading will allow for the abandonment of the two existing CMP culverts through the existing levee which provide site drainage at Stations 127+80 and 135+30 by the Southwest Sanitary Equalization Basin.

The interior flood control analysis for Area 3 involved computing the hypothetical frequency storm events and routing the runoff hydrographs through the outlet under design conditions. The interior ponding stage versus frequency curves are shown on plate A-27 and pertinent ponding stages are listed in table A-27. Also listed in table A-27 is the interior SPF gravity flow ponding stage. Design interior conditions result in ponding stages with only minor damage levels. Thus, pumping facilities are not economically feasible at Ponding Area D. The 48-inch gravity outlet represents the minimum facility to provide drainage through the levee for the 42-inch intercept storm sewer and Ponding Area D local drainage.

TABLE A-27

Area 3 - Interior Ponding Stages

Flood Event	Stage, City	Stage, NGVD
2-Year	29.9	803.7
10-Year	31.3	805.1
100-Year	32.7	806.5
SPF	33.7	807.5

AREA 4

Area 4 is a 20-acre residential watershed located mainly in the city of Des Moines adjacent to 63rd Street and a 10-acre industrial area located south of the Chicago-Northwestern Railroad tracks. A 36-inch RCP sewer outlet to the Raccoon River provides existing drainage for the 20-acre area. The stage versus damage data for this area are listed in table A-28. A 24" RCP outlet is recommended to provide local site drainage for the 10-acre parcel. The 36" outlet has an existing gatewell closure, however, it will need to be upgraded with a higher gatewell structure located at the levee intercept. The existing gatewell structure can remain since removal is not necessary. Blocked gravity conditions and excessively heavy rainfalls during gravity conditions will result in interior runoff ponding temporarily in the nearby streets. The stage versus storage curve for this existing ponding is shown on plate A-28.

TABLE A-28

Area 4 - Stage vs. Damage

Stage, City	Stage, NGVD	Damages, $
35.2	809.0	0
36.2	810.0	49,000
37.2	811.0	180,000
38.2	812.0	493,000

The analysis for Area 4 involved the multiple discrete events analysis of computing the hypothetical and discrete storm events and routing them through the existing 36-inch outlet and street ponding. A discrete event period-of-record of 43 years, 1947-1989, was used. These routings yielded the composite interior ponding curve shown on plate A-29 and pertinent ponding stages are listed in table A-29. Also listed in table A-29 is the interior SPF gravity flow ponding stage. The analysis computed a 100-year interior ponding elevation of 35.8 City datum (809.6 NGVD). This is 0.6 feet above the zero damage level of 35.2 City which corresponds to a 10-year frequency. Pumping alternatives were found to have insufficient supportable costs in the GRR; thus, pumping provisions are not recommended. The city of Des Moines will provide temporary pumping if excessive interior storm water accumulates.

TABLE A-29

Area 4 - Interior Ponding Stages

Flood Event	Stage, City	Stage, NGVD
2-Year	34.7	808.5
10-Year	35.2	809.0
100-Year	35.8	809.6
SPF	36.2	810.0

AREA 5

Area 5 is an 885-acre watershed tributary to the Raccoon River. The area consists of the central drainage basin of West Des Moines and includes the downtown and Holiday Park areas. Interior runoff from Area 5 is presently discharged to the Raccoon River through two storm sewer systems. A 6-foot by 6-foot RCB storm sewer outlet discharges at 8th Street and a 48-inch RCP storm sewer outlets between Fifth and Sixth Streets. Direct overland flow to the river has been impeded by the Chicago and Northwestern Railroad embankment. Capital improvement plans for the city of West Des Moines outline the city's intent to upgrade the existing storm drainage for the downtown area subsequent to the construction of the flood control project. These improvements include additional storm water collection sewers and outlets under the railroad embankment.

The recommended interior drainage plan for Area 5 includes excavating the available right-of-way between the 6th Street storm sewer outlet and the existing borrow pit adjacent to the proposed pump station location. Project function dictates that this area is necessary to satisfy Area 5 interior drainage needs of conveying blocked gravity flows to the pump station and incorporating the borrow pit into the site grading plan. Thus, the recommended Ponding Area C cannot be significantly reduced nor enlarged in size with the 8-acre size being dictated by project needs and topographic constraints. Therefore, alternative ponding area sizes were not studied. The site plan for Ponding Area C is shown on plate 26. The suitable excavated material will be used as project borrow. The proposed stage versus storage curve is shown on plate A-30. The gravity outlet was sized at a single 5-foot-high by 7-foot-wide RCB. The existing 6-foot by 6-foot RCB storm outlet (8th Street) will be gatewelled and intercepted with a 60-inch RCP leading to Ponding Area C during blocked gravity conditions. During Raccoon River stages below the closure elevation of 31.0 City datum, the storm sewer will outlet the same as it presently does. The same scenario will be used for the 48-inch RCP storm outlet (6th Street).

The 31.0 City datum closure elevation is consistent with present West Des Moines flood-fighting procedures. At this Raccoon River level, the flood gates are closed on the 6th and 8th Street storm sewers to prevent river backup on Railroad Avenue and surrounding low-lying areas. Railroad Avenue is a major arterial street in West Des Moines' transportation system. The inundation of low-lying areas adjacent to Railroad Avenue occurs approximately two feet before structural flood damages begin to occur in Area 5. Operationally, during real-time flood-fighting, these storm sewers closures will not be made if interior outflows are still occurring.

During blocked gravity conditions, the 48-inch outlet will be closed and flows will be diverted into a 78-inch RCP interceptor storm sewer leading to Ponding Area C. Gravity flows will discharge directly to the exterior of the levee for the 48-inch storm also. The anticipated future locally sponsored storm sewer improvements along Fourth Street will discharge directly into Ponding Area C. The gatewell structure will include a pump station to evacuate excess interior runoff during Raccoon River flood events which require closure. A layout of the interior plan is shown on plates 8, 9, 10 and A-38.

Since the existing gravity flow outlets are remaining in-place, the interceptor storm sewer's capacity was reduced to a two-thirds capacity for blocked gravity conditions. Rated capacities from the Storm Drainage Study were used in the computations. These capacities are listed in table A-30. Pertinent data concerning the interceptor storm sewer are listed in table A-31.

TABLE A-30

Area 5 - Storm Sewer Capacities

Name	Service Area, Acres	Size	Type	Capacity, Cfs
6th St.	161	48"	RCP	60
8th St.	140	72"	RCP	140

TABLE A-31

Area 5 - Interceptor Storm Sewers

Name	Design Capacity, Cfs	Size	Type	Slope, %
Area 5	100	60"	RCP	0.15
Area 5	200	78"	RCP	0.15

As with Area 2, pump station economic justification and optimization is based on the amount of residual interior damages which exist with the levee in-place and the benefits obtained by

reducing these damages versus the associated costs of providing pumping. A seepage allowance of 0.10 gpm/ft/ft was factored into the computations. The seepage analysis is found in the Geotechnical - Appendix C on plate C-87. The stage versus damages data for Area 5 are listed on table A-32.

TABLE A-32

Area 5 - Stage vs. Damage

Stage, City	Stage, NGVD	Damages, $
33.2	807	0
34.2	808	32,000
35.2	809	259,000
36.2	810	879,000
37.2	811	2,240,000
38.2	812	3,430.000
39.2	813	4,750,000
40.2	814	5,860,000
41.2	815	6,820,000

The interior Flood control analysis involved computing the hypothetical frequency and discrete period-of-record storm events and routing these storms through the interior flood control facilities. Pumping capacities of 10,000, 25,000, 35,000, 50,000 and 75,000 gpm were also evaluated. These routings yielded the interior ponding versus frequency curves shown on plate A-31.

The incremental costs of adding pumping to the ponding area gravity outlet gatewell structure are listed in table A-33. These costs are based on a 100-year design period with a 8-7/8 percent interest rate. Annualized replacement, energy, and maintenance costs are also factored in.

TABLE A-33

Area 5 - Pump Size vs. Cost

Size, Gpm	First Cost, $	Annualized Cost, $				
		First	Replace	Energy	Maint.	Total
10,000	75,000	6,700	300	400	3,000	10,000
25,000	110,300	9,800	500	400	3,000	13,700
35,000	156,200	13,900	700	400	4,500	19,500
50,000	165,400	14,700	700	400	4,500	20,300
75,000	275,700	24,500	1,200	400	7,500	33,600

The economic damage-benefit-cost data for the benefits derived from providing pumping versus the cost of providing pumping are summarized in table A-34.

TABLE A-34

Area 5 - Pumping Station Benefits vs. Cost

Size, Gpm	Annual Benefits, $	Annual Cost, $	Net Benefits, $	BCR	Residual Damages, $
No Pump	- 0 -	- 0 -	- 0 -	-	212,900
10,000	145,900	10,400	135,500	14.0	67,000
25,000	195,900	13,700	182,200	14.3	17,000
35,000	209,100	19,500	189,600	10.7	3,800
50,000	212,700	20,300	192,400	10.5	200
75,000	212,900	33,600	179,300	6.3	0

As indicated in table A-34, the optimized pump station size is the 50,000 gpm pumping rate with a net benefit of $192,400. Thus, the 50,000 gpm pumping rate is the selected size pump station. An annual residual interior damage associated to the levee project is $200 for this pumping rate. This design results in a residual 100-year interior flood elevation of 32.2 City datum. Pertinent interior ponding stages for the selected 50,000 gpm pump station are listed in table A-35. Also listed in table A-35 is the interior SPF gravity flow ponding stage.

TABLE A-35

Area 5 - Interior Ponding Stages

Flood Event	Stage, City	Stage, NGVD
2-Year	31.0*	804.8
10-Year	31.0*	804.8
100-Year	32.1	805.9
SPF	No Increases vs. Existing Conditions	

* Stage 31.0 City datum represents the gatewell closure elevation, subsequent pumping will draw the ponding level down to elevation 29.0.

AREA 6

Area 6 is a 1,125-acre watershed tributary to the Raccoon River. The watershed's channel has been named Fairmeadows Creek. The watershed consists of upland residential development, and the

floodplain area is commercial and industrial property. The stage versus damage data for Area 6 are listed in table A-36. Interior runoff from the watershed flows in a southeasterly direction to the river through a complex drainage system. The location of the watershed is shown on plate A-3 and A-21.

TABLE A-36

Area 6 - Stage vs. Damage at Line-of-Protection

Stage, City	Stage, NGVD	Damage, $
41.2	815.0	0*
42.2	816.0	10,000*
43.2	817.0	160,000*
44.2	818.0	960,000*
45.2	819.0	1,785,000*
46.2	820.0	2,470,000
47.2	821.0	3,034,000

* These interior damages do not begin to occur until Ponding Area A exceeds elevation 46.2. This is due to Ponding Area A being situated in an upland location remote from the levee alignment.

The headwaters of Fairmeadows Creek are located west of 35th Street and north of Ashworth Road. The defined creek channel begins south of Ashworth Road. The creek flows in a southeasterly direction and crosses under 32nd, 27th and 22nd Streets, Grand Avenue and the Chicago-Northwestern Railroad. Some retention storage is provided at the 22nd Street road embankment. The channel continues eastward adjacent to a mobile home park. From this point, Fairmeadows Creek enters an existing 27-acre detention storage area. The existing capacity of this detention area is 65 acre-feet. The existing stage vs. storage capacity of this area is shown on plate A-32. The detention area has an ungated 36-inch RCP discharge structure which restricts downstream outflows through an industrial area. The 36-inch outlet has an estimated capacity of 90 cfs when the detention area is full. The site was originally constructed by a downstream private business. However, the city of West Des Moines has since acquired ownership of the detention area property.

Downstream of the detention area, the Fairmeadows Creek flows through the industrial area via a combination of concrete-lined open channels, box culverts and pipes until it reaches the Chicago and Pacific Railroad. The channel in this reach has an estimated capacity of 150 cfs. In this industrial area, many surface depressions serve as localized ponding areas with no apparent discharge points. The stormwater in these depressions does not substantially contribute to runoff at this time. Future

re-development of this area will improve the drainage patterns. This expected re-development was considered in the recommended interior drainage facilities. A twin 5.5 by 6- foot RCB culvert exists under the railroad, and downstream is a twin 72-inch RCP culvert under Lincoln Road.

The Storm Drainage Study concludes that the existing detention area will be overloaded by Fairmeadows Creek storms exceeding a 10-year event during gravity flow conditions. District HEC-1 modelling of the Fairmeadows Creek watershed has verified this conclusion. Additionally, the existing detention site capacity is inadequate for the 1.6 square mile upstream watershed during blocked gravity conditions, providing less than 1-inch of basin runoff storage.

Soil borings obtained in the 27-acre detention area have found the soil to be an excellent material for levee construction. Thus, upgrading the detention area into a ponding area for the levee project by deepening it would double as a source of economical on-site borrow material. A grading plan to provide an additional 75 acre-feet of ponding capacity was developed. The total ponding capacity of 140 acre-feet has been determined the amount necessary to provide 100-year capacity for the design interior flood analysis.

The upgrading will involve deepening the existing detention area as shown on plate 24 by an average of approximately three feet. Drainage from the area will continue to be via gravity flows. Additionally, a gated 48-inch RCP outlet structure will be installed in-place of the ungated 36-inch outlet. The stage versus storage capacity curve for the upgraded Ponding Area A is shown on plate A-32.

The recommended gravity outlet at the levee intercept of Fairmeadows Creek is a twin 72-inch RCP gated outlet. This structure corresponds to immediate upstream culvert sizes under the Chicago and Pacific Railroad and Lincoln Street. A site plan for this area is shown on plate 7 and 24.

As shown on plate 2, Ponding Area A is located upstream of the levee alignment with development in-between. Thus, the operation plan will be that under gravity flow conditions on the Raccoon River, the 48-inch ponding area outlet will be open with outflows not exceeding the downstream 150 cfs channel capacity. Upon closure of the gatewell at the levee, the ponding area outlet also would be closed. Of note is the fact that these outlets lie on the upper fringes of the Raccoon River floodplain and historically, 1915-1990, the river has not backed up the culvert to damaging levels in this area. This results in no economic justification for installing pumping from a period-of-record type analysis.

The interior flood control analysis for Area 6 involved computing the hypothetical and discrete period-of-record storm events and

routing them through the upgraded Ponding Area A. Pumping alternatives were not evaluated due to the lack of closure periods with interior runoff in the period-of-record. Seepage was determined to be not applicable for this area, thus no seepage allowance was included in the computations. The routings yielded the composite interior ponding curve shown on plate A-33 and pertinent ponding stages are listed in table A-37. Also listed in table A-37 is the interior SPF gravity flow ponding stage.
The analysis computed a 100-year interior ponding elevation of 46.2 City datum. Blocked gravity routings indicated the ponding/borrow area will be able to store Fairmeadows Creek interior runoff for flood events up to a 10-year frequency. Excessive local drainage accumulations between Ponding Area A and the levee will be evacuated by the city of West Des Moines via temporary pumps. Again, historically, a damageable blocked gravity condition has not occurred.

TABLE A-37

Area 6 - Ponding Area A Stages

Flood Event	Stage, City	Stage, NGVD
2-Year	41.8	815.6
10-Year	43.8	817.6
100-Year	46.2	820.0
SPF	48.3	822.1

Area 7

Area 7 is a 55-acre watershed tributary to the Raccoon River. The watershed consists of commercial and industrial development and is outletted by a 36-inch RCP culvert under the Chicago and Pacific Railroad. The stage versus damage data for Area 7 are listed in table A-38. Immediately downstream is an 18-inch RCP culvert under an at-grade access road and then the proposed levee alignment. Downstream of the access road, a sand and gravel operation has disturbed the drainage path to Jordan Creek. The city of West Des Moines has indicated that South 11th Street may be extended through this area and that the drainage at the railroad might be improved. However, these improvements are conceptual with no definite plans. The interior drainage plan for this area is for the city of West Des Moines to acquire the existing 3-acre low area upstream of the railroad embankment. No additional excavation is recommended to increase the storage capacity; however, cleanouts of the existing railroad culvert are necessary. The ponding location is shown on plate 25 as Ponding Area B. The stage versus storage curve is shown on plate A-34.

TABLE A-38

Area 7 - Stage vs. Damage

Stage, City	Stage, NGVD	Damage, $
44.2	818.0	0
45.2	819.0	20,000
46.2	820.0	45,000

A 48-inch RCP gravity outlet with gatewell closure is recommended at the levee downstream of the railroad embankment. This 48-inch outlet line will replace the existing 18-inch pipe under Lincoln Road. The additional size of this 48-inch gravity outlet versus the 36-inch ponding area outlet is to accommodate the local drainage from Lincoln Road. A downstream outlet ditch will need to be provided to Jordan Creek, as previous sand and gravel mining operations have obstructed the natural drainage course. The recommended layout is shown on plate 25. Again, as with Area 6, the levee outlet is located at the upper fringe of the Raccoon River floodplain with closure required only during extreme flood events.

The interior flood control analysis for Area 7 involved computing the hypothetical and discrete period-of-record storm events and routing them through the ponding area and railroad culvert. These routings yielded the composite interior ponding curve shown on plate A-35 and pertinent ponding stages are listed in table A-39. Also listed in table A-39 is the interior SPF gravity flow ponding stage. Pumping alternatives were found to have no supportable costs in the GRR study. The infrequent required closures of this outlet support this finding. Thus, pumping alternatives were not evaluated in this study phase. The 100-year ponding level is 43.7 City datum. This ponding level is contained primarily within the existing low area and is below the zero damage level of 44.7 City datum.

TABLE A-39

Area 7 - Interior Ponding Stages

Flood Event	Stage, City	Stage, NGVD
2-Year	41.2	815.0
10-Year	42.5	816.3
100-Year	43.7	817.5
SPF	45.2	819.0

INTERIOR FLOOD CONTROL PROJECT OPERATION

The formulation and design of the project has resulted in a plan that includes ten interior flood control gatewell closures; three affected by Walnut Creek and seven on the Raccoon River. Seven of the gatewell closures will be West Des Moines responsibility and three will be Des Moines. This section will discuss the ope ation of the interior flood control facilities and will outline functional local responsibilities. Pertinent information on each of the interior drainage outlets is listed on table A-40.

Walnut Creek

The interior flood control facilities affected by Walnut Creek (Areas 1, 2 & 3) were formulated and designed with the limited advance warning time as a design parameter. Flood warning and response for Walnut Creek is addressed in detail in Addendum A. The cities will be placed on alert whenever the NWS issues a Flash Flood Warning bulletin or when an alarm warning parameter in the ALERT system is exceeded. The locals will then monitor the ALERT system and NWS forecasts on a regular basis to keep abreast of any developing flood situation. Additionally, initial mobilization of emergency responses will be coordinated in this alert phase.

Upon observation through the ALERT system that Walnut Creek basin rainfalls are exceeding the NWS Flood Advisory Table basin index rainfall to cause flood stage or flood stage is reached at any of the three stream gages, official mobilization will commence. Interior drainage facilities will need initial flood response.

Presently, there are twelve interior outlet locations draining to Walnut Creek. These twelve outlets are recommended to be collected via interceptor storm sewers and surface grading into three outlets. The interior drainage outlets will be equipped with gatewell structures at the levee. Each gatewell will have a sluice gate for positive closure during periods when flood levels exceed interior ponding levels. The sluice gates can be readily closed in fifteen to twenty minutes each.

The 63rd Street gage on Walnut Creek will serve as the focal point for when closure of each gatewell should be made. The gatewells are located at Station 147+00 by Valley Drive, at Station 187+85 on 63rd Street, and at Station 202+70 on Hoak Drive. The city of Des Moines will be responsible for the Valley Drive gatewell with the other two gatewells being West Des Moines' responsibility. A stage of 13.5 feet will be the closure decision point. This is the level which the city of West Des Moines has historically found as the best for initiating flood-fighting activities on Walnut Creek as it represents the level at which interior flooding begins in Area 2. Since these gatewell

closures will typically occur during periods of rainfall, actual closure should occur when interior outflow ceases and floodwater backup commences at each location. The Walnut Creek gatewell closure data are tabulated on table A-41.

Raccoon River

As discussed in the roadway/railroad closure procedures and in Addendum A, the flood fighting procedures to guard against Raccoon River flooding have been institutionalized for each city. The advance warning time available is ample for the locals to perform the required interior flood control operations. The cities will be placed on an initial alert for monitoring of Raccoon River stream gages whenever the NWS issues a Flood Warning Bulletin on the Raccoon River basin. A secondary alert level will correspond to West Des Moines present "green" alert. This will occur when the stage at Van Meter reaches 13.0 feet (expectant 31.0 at 63rd Street in West Des Moines). At this level, the river is still within its bank, however, backup is beginning which requires closure of the gatewells at Stations 59+50, 67+50, 81+50 and 103+50. The closure at Station 81+50 will include activating the pump station. Interior levels in Ponding Area C will be subsequently pumped down to 29.0. The pumping schedule will include a pump on level of 30.0 after this initial closure and drawdown. The gatewells associated with Ponding Area C and the pump station operation will be the city of West Des Moines responsibility. The gatewell at Station 103+50 will be the city of Des Moines. The pertinent data for these closures are tabulated on table A-41.

The site drainage gatewell at Station 100+45 will require closure next if the river exceeded a stage of 34.0 feet. This closure will be handled by Des Moines.

The last two Raccoon River affected gatewell closures are located on Fairmeadows Creek at Station 43+60 and the Lincoln Road outlet at Station 13+50. The mobilization for closure on Fairmeadows Creek is at a stage of 37.0. The outlet should be monitored such that actual closure is not made until Raccoon River tailwaters are forcing interior flows outside the Fairmeadows Creek channel. At this point, the gatewell at Ponding Area A should be closed first and then the levee gatewell. The Lincoln Road gatewell should be monitored for closure at a stage of 38.5. Table A-41 lists the pertinent data on these gatewells also.

TABLE A-40

INTERIOR DRAINAGE OUTLET SUMMARY

STATION	13+50	43+60	59+75	67+50	81+50	100+45	103+50	147+00	187+85	202+70
	GENERAL									
NAME	LINCOLN	F CREEK	8th ST.	6th ST.	P.A. C	63rd ST	C-NW RR	VALLEY	63rd ST	HOAK
INTERIOR AREA	7	6	5	5	5	4	4	3	2	1
IDENT. LETTER	B	C	D	E	F	G	H	M	O	Q
REFERENCE PLATE	5	7	8	9	10	12	12	16	19	20
DRAINAGE AREA, AC	56	1125	626	161	885	10	20	150	160	18
	CONDUIT DATA									
SIZE	48"	2-72"	6'X6'	48"	5'X7'	24"	36"	48"	5'X7'	24"
TYPE	RCP	RCP	RCB	RCP	RCB	RCP	RCP	RCP	RCB	RCP
INVERT. ELEV, CITY	36.5	34	27	26.5	25.7	31	25.4	26.5	30.5	39
DESIGN CFS	36.5	34	27	26.5	25.7	31	25.4	26.5	30.5	39
	CLOSURE ELEVATIONS									
@ SITE CITY	40	38	31.8	31.7	31.5	33.5	30.5	30.2	39.7	40.7
* @ GAGE, GAGE	20.5	19	13	13	13	16	13	13.5	13.5	13.5
** @ GAGE, CITY	38.5	37	31	31	31	34	31	40.7	40.7	40.7
	RIVER FLOOD DATA									
OUTLET STREAM	RACOON	RACCOON	RACCOON	RACCOON	RACCOON	RACCOON	RACCOON	WALNUT	WALNUT	WALNUT
LEVEE DESIGN Q, CFS	53000	53000	53000	53000	53000	53000	53000	17000	17000	17000
LEVEE DESIGN STAGE	47.9	46.8	46.3	46	45.5	44.5	44.2	42.2	51.4	52.9
DURATION ABOVE CLOSURE, % TIME	<1	<1	2	2	2	1	2	<1	<1	<1

* 63rd STREET, WALNUT CREEK GAGE
VAN METER, RACCOON RIVER GAGE

** 63rd STREET, WALNUT CREEK GAGE
63rd STREET, RACCOON RIVER GAGE

Note: 0.0 FT., CITY DATUM = 773.8 FT., NGVD

TABLE A-41

SUMMARY OF GATEWELL CLOSURES
WEST DES MOINES-DES MOINES, IOWA

STATION	LOCATION	AFFECTED BY	CITY	GATEWELL DIM. (DIA IN) (HxW,FT)	TYPE	ALERT STAGE GAGE (FT) *1	ALERT STAGE CITY (FT) *2	ALERT Q (CFS)	ALERT FREQ (YR)	MOBILIZATION STAGE GAGE (FT) *1	MOBILIZATION STAGE CITY (FT) *2	MOBILIZATION Q (CFS)	MOBILIZATION FREQ (YR)	ZERO DAMAGE LEVEL STAGE GAGE (FT) *1	ZERO DAMAGE LEVEL STAGE CITY (FT) *3	ZERO DAMAGE LEVEL Q (CFS)	ZERO DAMAGE LEVEL FREQ (YR)	CLOS. TIME (HR)	AVAIL. TIME (HR)	SAFETY FACTOR
13+50	LINCOLN RD FAIR	RACCOON	WDM	48"	SLUICE	13	31	8500	1.25	22	38.5	28,000	9	26.7	44.7	60,000	200	.25	15+	60+
43+60	MEADOWS	RACCOON	WDM	2-72"	SLUICE	13	31	8500	1.25	20	37	23,000	5	26.2	44.2	45,000	50	.50	15+	30+
59+75	8th St.	RACCOON	WDM	6'x6'	SLUICE	13	31	8500	1.25	13	31	8,500	1.25	17.2	35.2	17,000	3	.25	15+	60+
67+50	6th ST	RACCOON	WDM	48"	SLUICE	13	31	8500	1.25	13	31	8,500	1.25	17.2	35.2	17,000	3	.25	15+	60+
81+50	63rd ST	RACCOON	WDM	5'x7'	SLUICE	13	31	8500	1.25	13	31	8,500	1.25	17.2	35.2	17,000	3	.50	15+	30+
100+45	63rd ST	RACCOON	DM	24"	SLUICE	13	31	8500	1.25	16	34	14,000	2	17.2	35.2	17,000	3	.25	15+	60+
103+50	C-NW RR	RACCOON	DM	36"	SLUICE	13	31	8500	1.25	13	31	8,500	1.25	17.2	35.2	17,000	3	.25	15+	60+
147+00	VALLEY DR	WALNUT	DM	48"	SLUICE	Nat. Weather Serv. Flood Warning Bulletin or ALERT System Alarm Warning				13.5	40.7	3,000	2	19.0	35.2	9,500	20	.25	2	8
187+85	63rd ST	WALNUT	WDM	5'x7'	SLUICE					13.5	40.7	3,000	2	14.5	40.2	3,800	3	.33	2	6
202+70	HOAK DR	WALNUT	WDM	24"	SLUICE					13.5	40.7	3,000	2	15.5	43.2	4,400	4	.25	2	8

Forecasted

Forecasted

Forecasted

*1 Stage @ Van Meter Gage, 0.0 = 841.2 NGVD
Stage @ 63rd Street Gage, 0.0 = 801.0 NGVD

*2 Stage @ 63rd Street, Racoon/Walnut, 0.0 = 773.8 NGVD

*3 Stage @ Site Location, 0.0 = 773.8 NGVD

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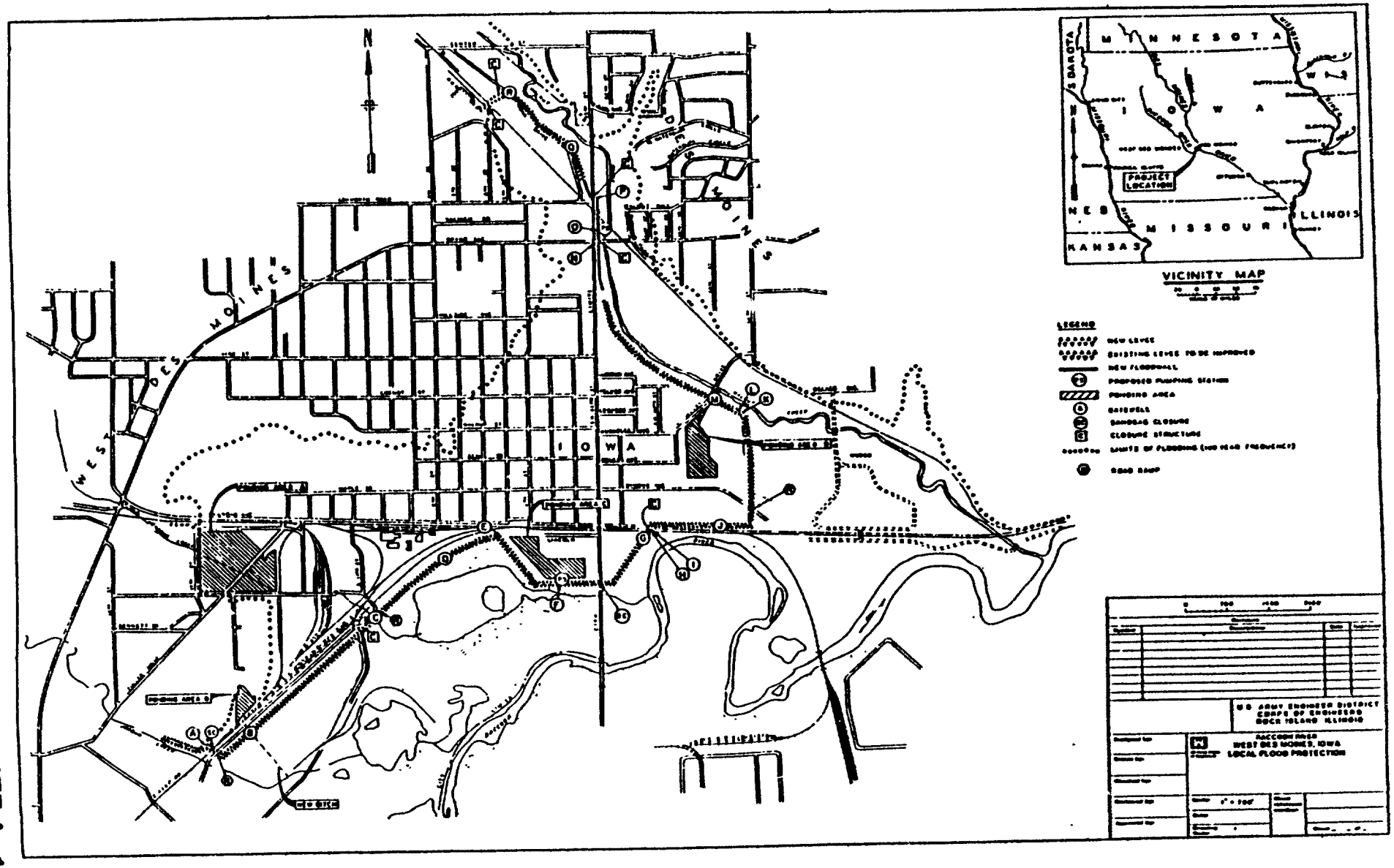
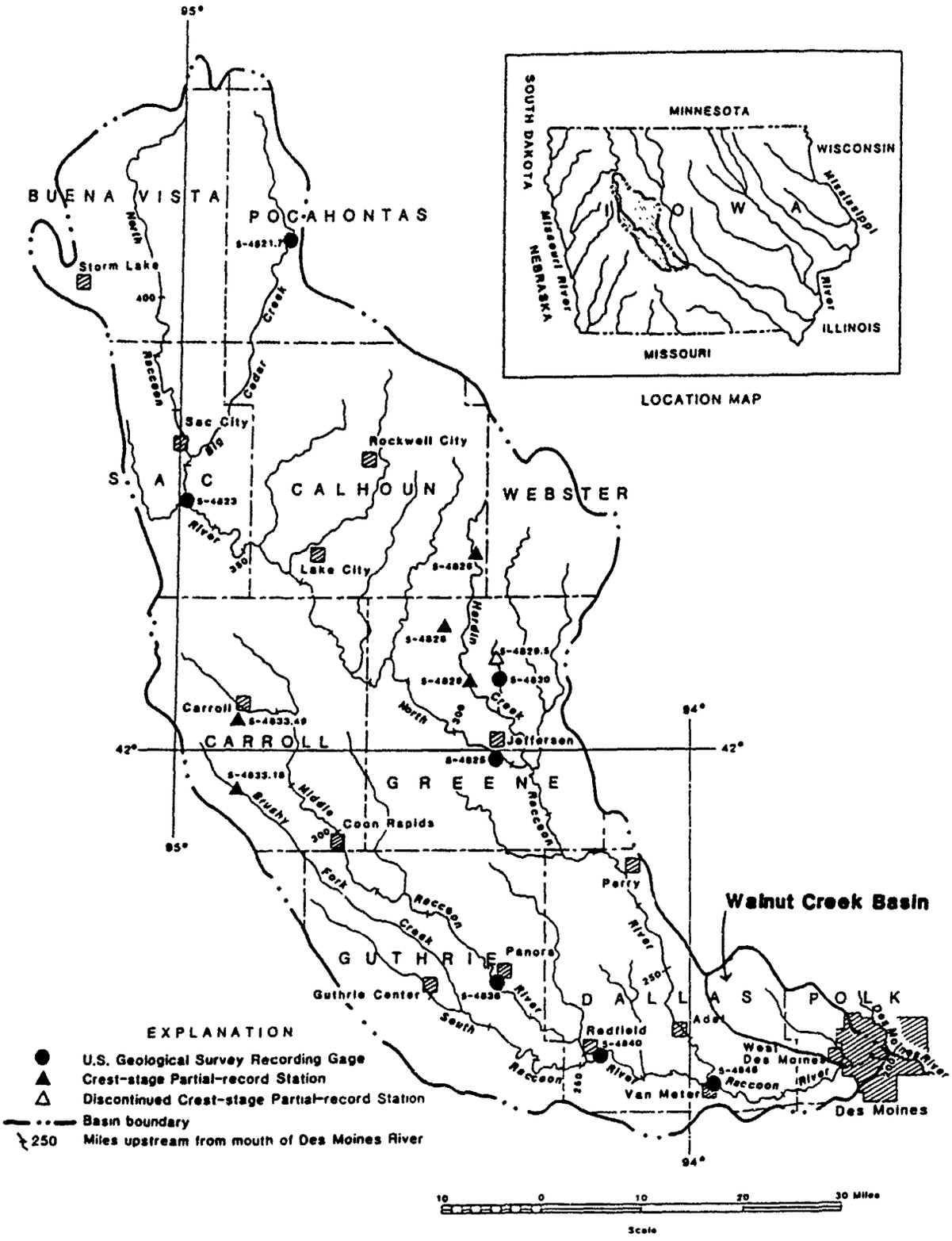

N
WEST DES MOINES
DES MOINES
IOWA
MINNESOTA
S DAKOTA
NEB
KANSAS
MISSOURI
ILLINOIS
PROJECT LOCATION
VICINITY MAP
LEGEND
NEW LEVEE
EXISTING LEVEE TO BE IMPROVED
NEW FLOODWALL
PROPOSED PUMPING STATION
PONDING AREA
GATEWELL
DAMDRAIN CLOSURE
CLOSURE STRUCTURE
LIMITS OF FLOODING (100 YEAR FREQUENCY)
ROAD RAMP
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND ILLINOIS
WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

PLATE A-1



Raccoon River Basin

PLATE A-2

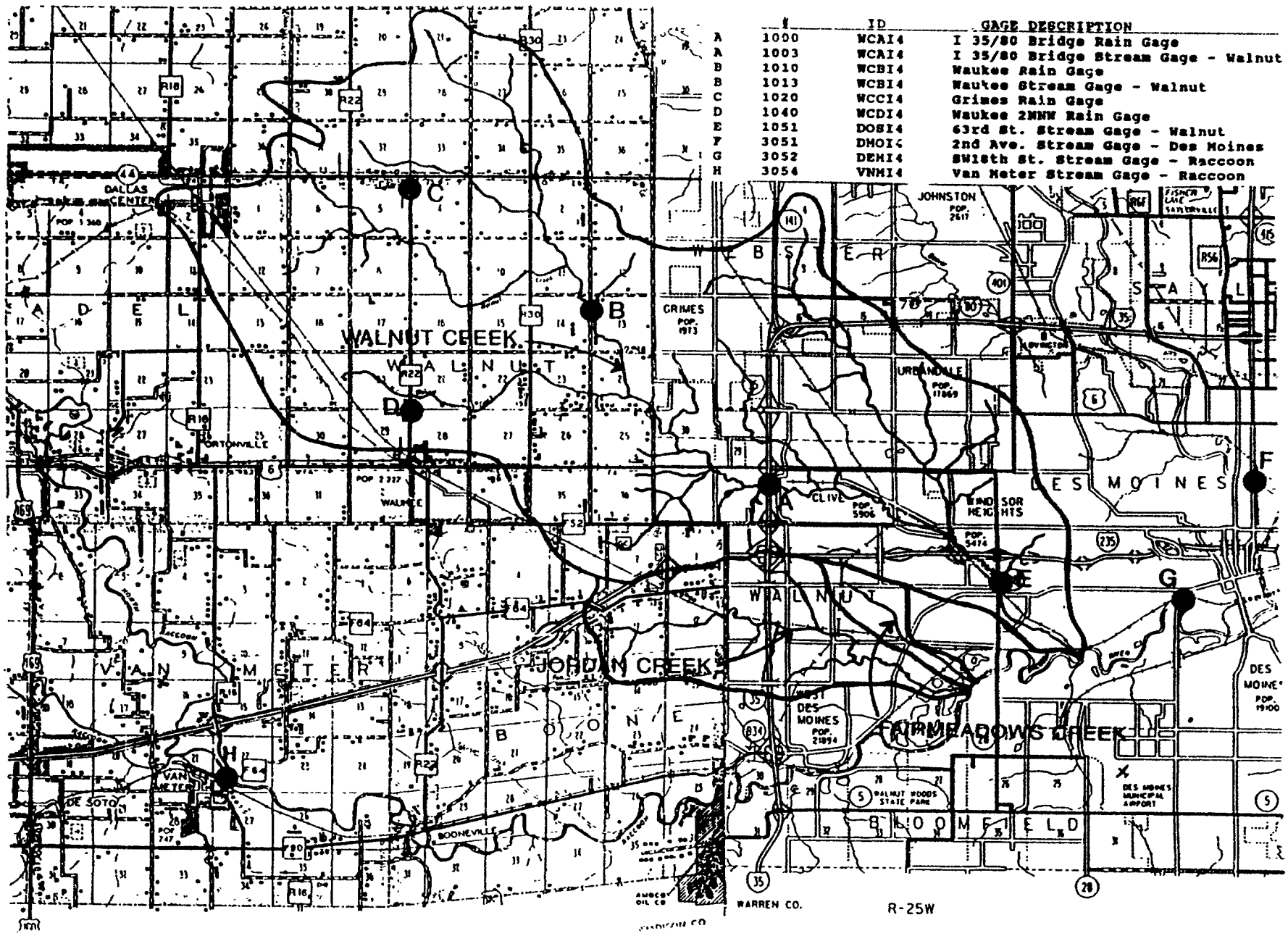

WALNUT CREEK
JORDAN CREEK
FARM CREEK
WALNUT CREEK
DES MOINES
JOHNSTON
GRIMES
DALLAS CENTER
ADEL
WAUKEE
CLIVE
WINDSOR HEIGHTS
URBANDALE
VAN METER
DE SOTO
BOONEVILLE
DES MOINES
BLOOMFIELD
WARREN CO.
R-25W
A 1000 WCAI4 I 35/80 Bridge Rain Gage
A 1003 WCAI4 I 35/80 Bridge Stream Gage - Walnut
B 1010 WCBI4 Waukee Rain Gage
B 1013 WCBI4 Waukee Stream Gage - Walnut
C 1020 WCCI4 Grimes Rain Gage
D 1040 WCDI4 Waukee 2NNW Rain Gage
E 1051 DOBI4 63rd St. Stream Gage - Walnut
F 3051 DMOI4 2nd Ave. Stream Gage - Des Moines
G 3052 DEMI4 SW18th St. Stream Gage - Raccoon
H 3054 VNMI4 Van Meter Stream Gage - Raccoon

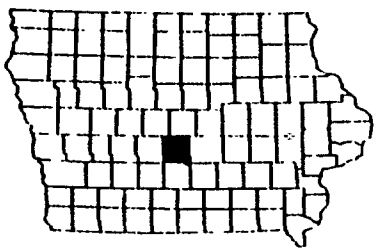
PLATE A-3

WALNUT CREEK

URBANIZATION TRENDS

WEST DES MOINES, IOWA

Prior to 1970, the development in Clive, Urbandale and West Des Moines was located inside the I-35/80 highways on the metro area's northwest side.



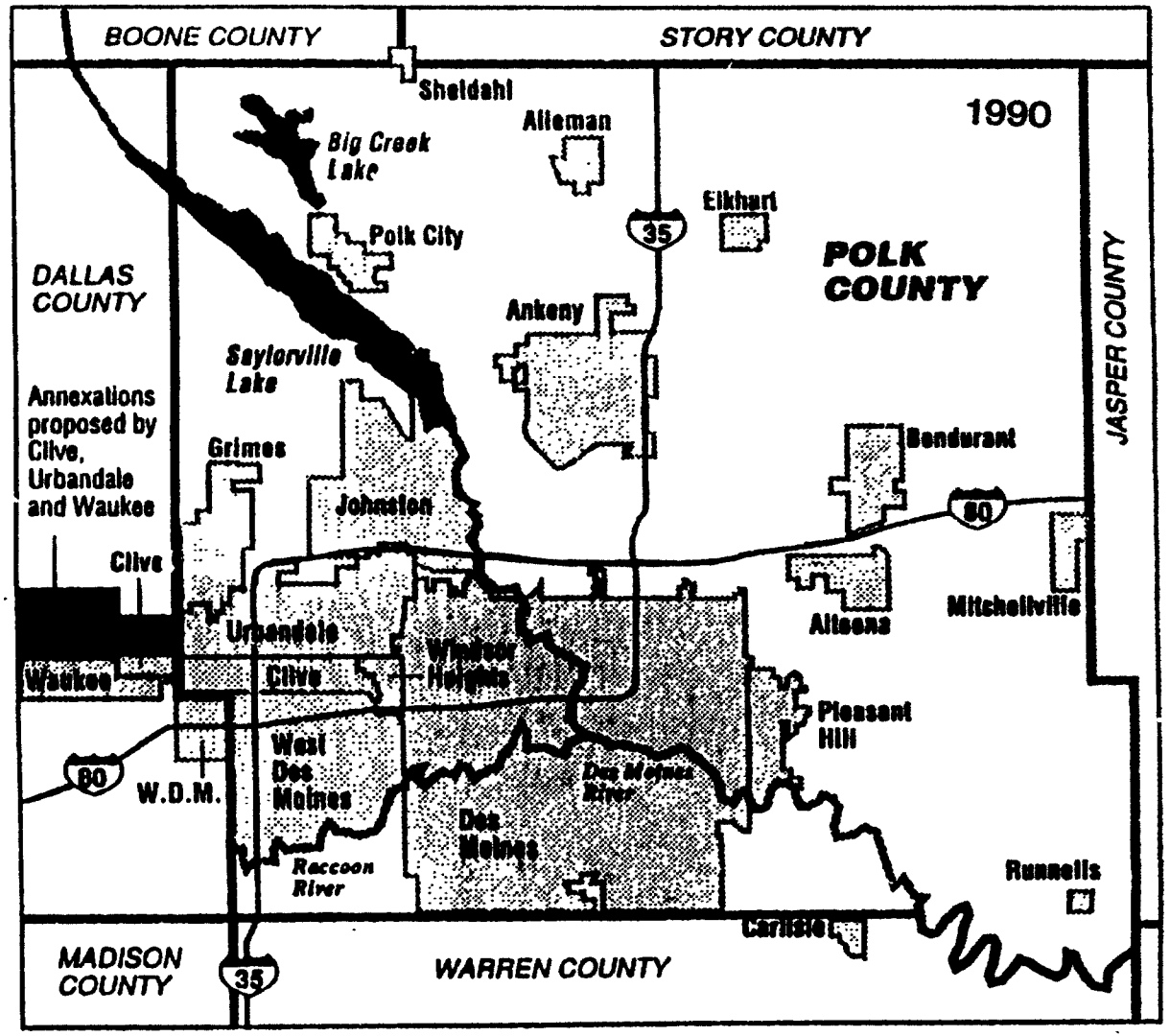


PLATE A-4

Maximum flood peaks at gaging stations in the Raccoon River basin, Iowa

Station number	Gaging station	Period of flood record	Drainage area (mi^2)	Maximum flood AS OF 1979			
				Date	Gage height (ft)	Discharge (ft^3/s)	Recurrence interval (yrs)
05482170	Big Cedar Cr. nr Varina	1960-79	80.0	8/31/62	13.68	2,080	13
05482300	North Raccoon R. nr Sac City	1954, 1959-79	713	3/23/79	17.96	12,800	55
05482500	North Raccoon R. nr Jefferson	1940-79	1,619	6/23/47	22.3	29,100	*
05482600	Hardin Cr. at Farnhamville	1952-79	43.7	8/26/54	10.48	2,000	45
05482800	Happy Run at Churdan	1951-79	7.58	3/25/62	8.57	150	2
05482900	Hardin Cr. nr Farlin	1951-79	101	3/29/51	12.97	2,270	11
05482950	East Fork Hardin Cr. nr Paton	1952-55	7.57	3/24/53	7.77	68	1
05483000	East Fork Hardin Cr. nr Churdan	1952-79	24.0	5/5/60	8.92	413	2
05483318	Brushy Fork Cr. nr Templeton	1966-79	45.0	6/23/74	90.96	+	-
05483349	Middle Raccoon R. trib. at Carroll	1966-79	6.58	5/23/76	91.06	680	50
05483600	Middle Raccoon R. at Panora	1953, 1958-79	440	5/19/74	14.80	14,000	17
05484000	South Raccoon R. at Redfield	1940-79	988	7/2/58	29.04	35,000	*
05484500	Raccoon R. at Van Meter	1915-79	3,441	6/13/47	21.37	41,200	50

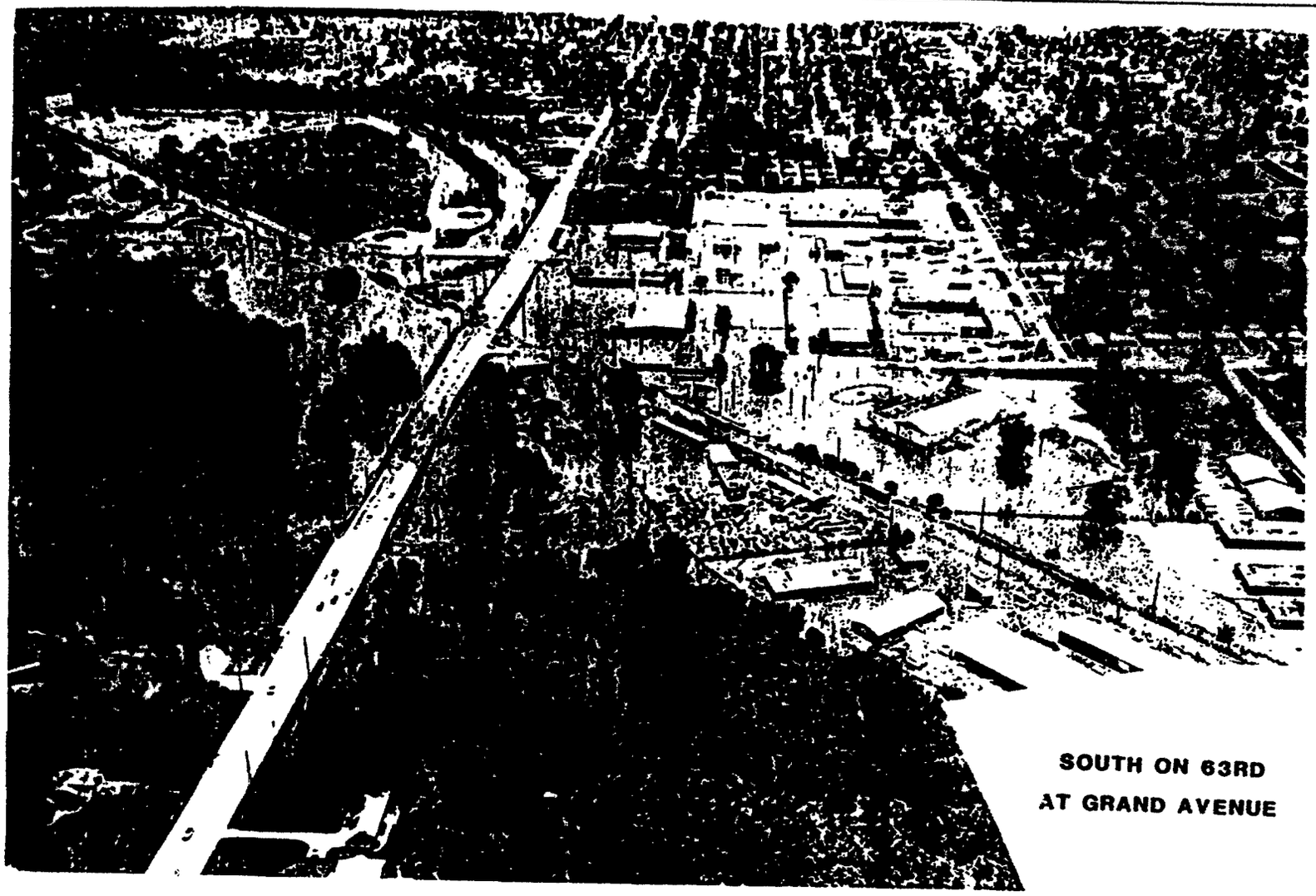
* Greater than the 100-year flood discharge
\+ Discharge not determined

PLATE A-5

WALNUT CREEK

JULY 1973 FLOOD

WEST DES MOINES, IOWA



SOUTH ON 63RD
AT GRAND AVENUE

PLATE A-6

RACCOON RIVER	WEST DES MOINES, IOWA
DISCHARGE VS. FREQUENCY	

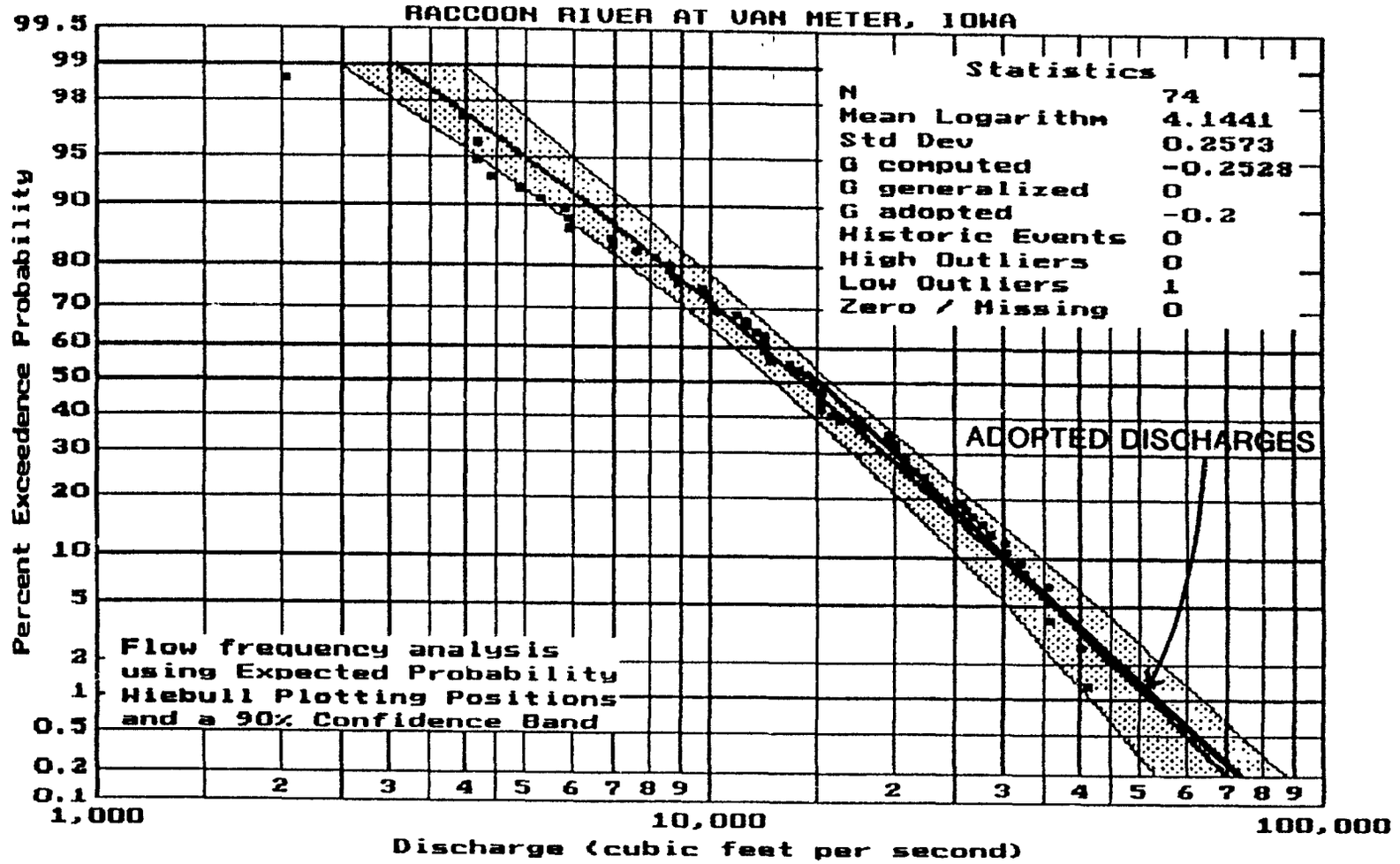


PLATE A-7

WALNUT CREEK

DISCHARGE VS. FREQUENCY

WEST DES MOINES, IOWA

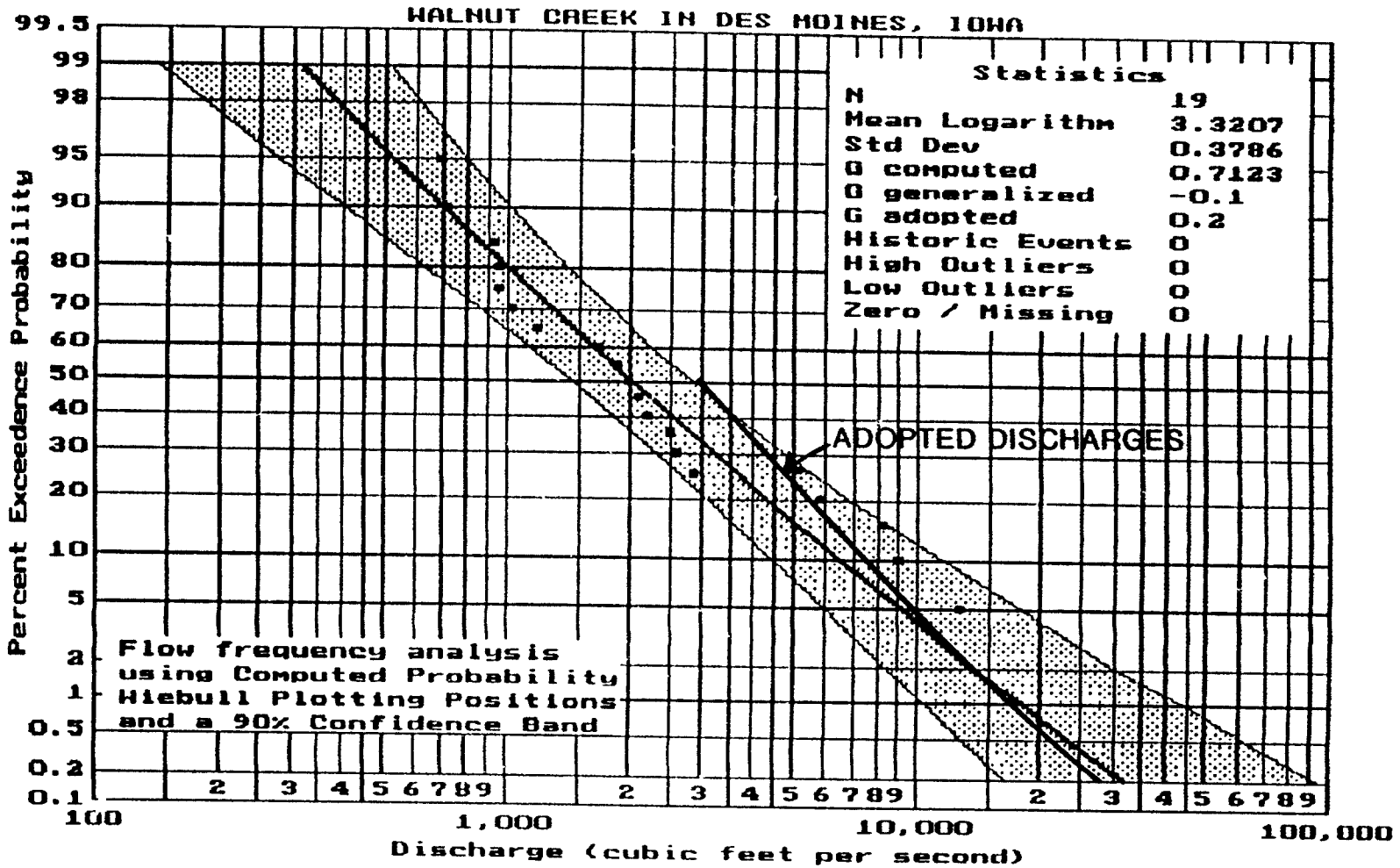


PLATE A-8

WALNUT CREEK

MAY 1986 FLOOD HYDROGRAPH

WEST DES MOINES, IOWA

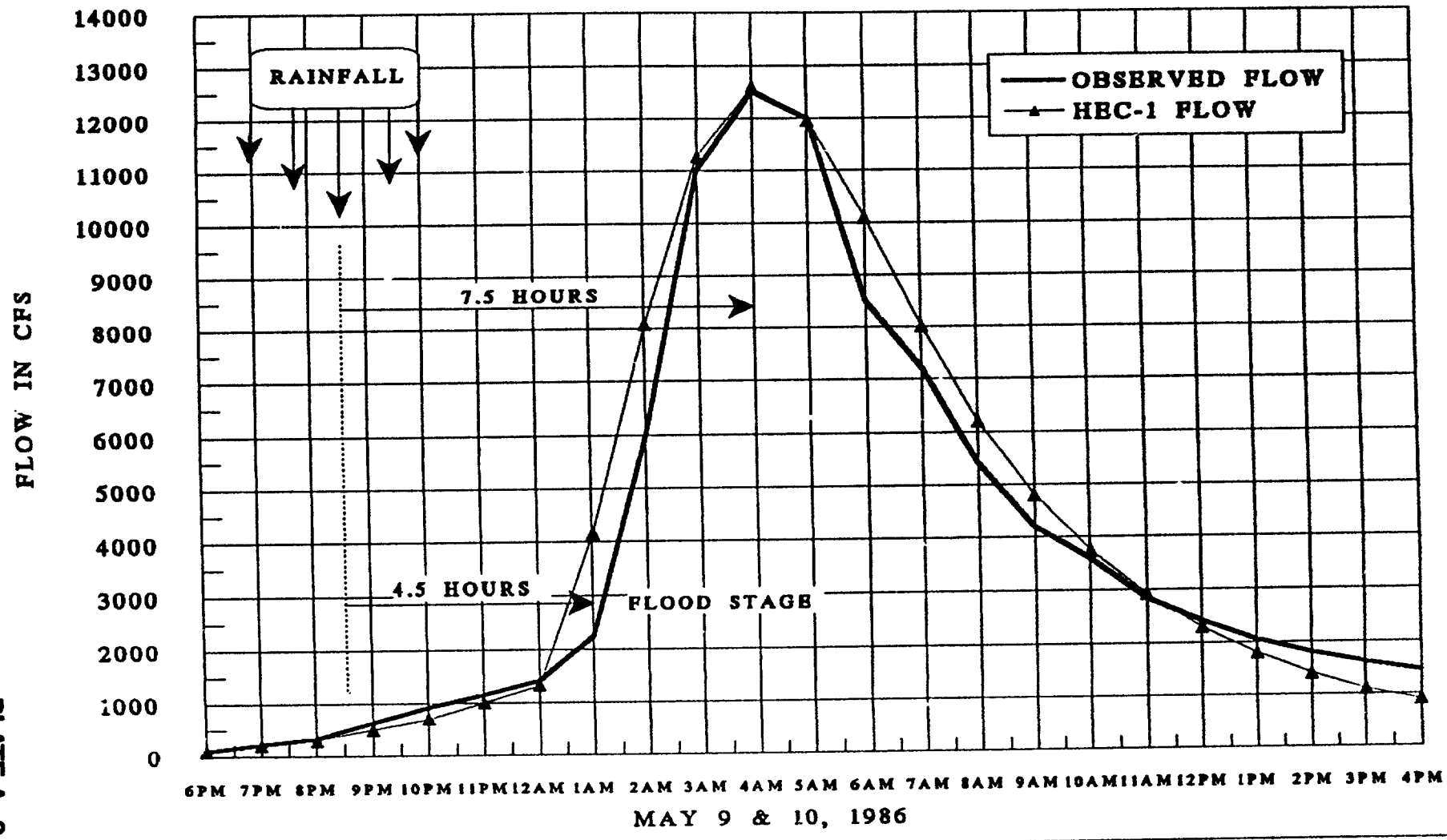


PLATE A-9

JORDAN CREEK	WEST DES MOINES, IOWA
DISCHARGE VS. FREQUENCY	

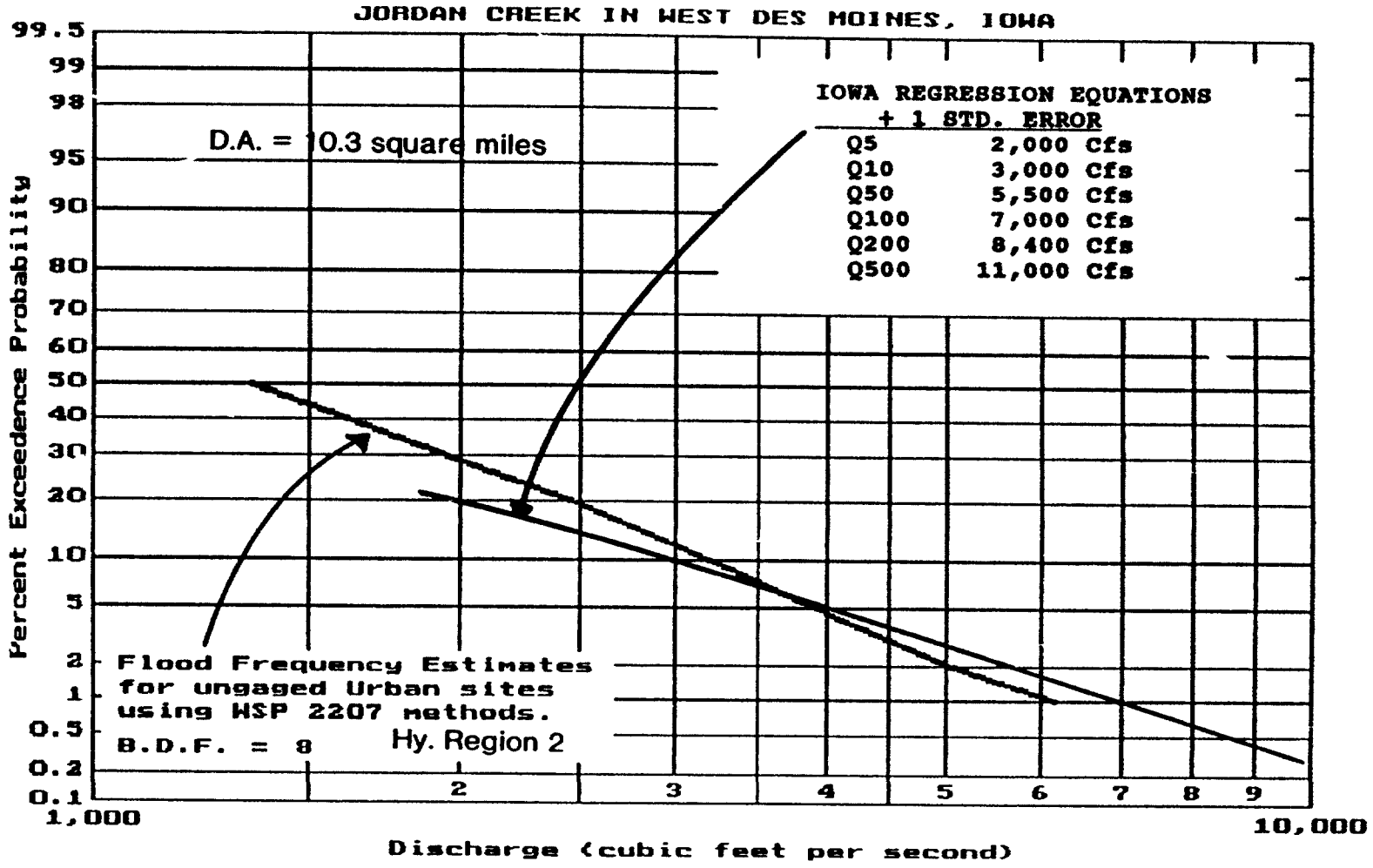


PLATE A-10

RACCOON RIVER STANDARD PROJECT FLOOD	WEST DES MOINES, IOWA

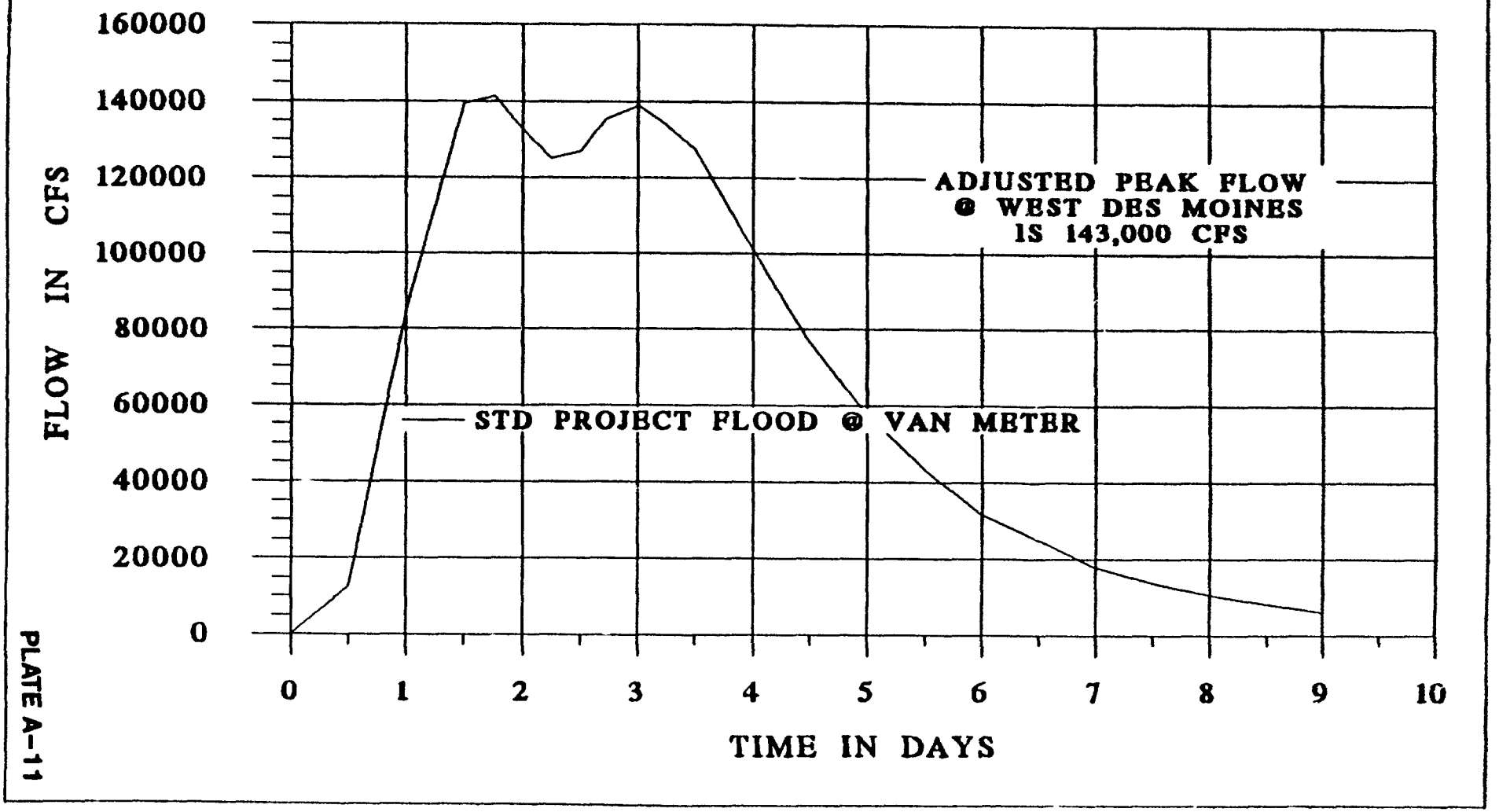


PLATE A-11

DESIGN MEMORANDUM
FOR
FLOOD CONTROL PROJECT
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA

APPENDIX C
GEOTECHNICAL

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GEOLOGY AND SOILS

LOCATION

The project is located in eastern West Des Moines, Walnut Township and in western Des Moines, Des Moines Township, Polk County, Iowa. The site is situated just north of the Raccoon River and just west of Walnut Creek. Physiographically, the area lies on the border between the Des Moines Lobe and the Southern Iowa Drift Plain of the Dissected Till Plain in the Central Lowland Physiographic Province (Prior 1976).

PHYSIOGRAPHY

The Raccoon River Valley is believed to have begun its development during the Aftonian interglacial period (plate C-1). At that time, the main drainage from the north passed a few miles east of the project. The Cary substage of the Wisconsinan glacial stage reached the Raccoon River (Bain 1896) and is the youngest glacial landscape found in Iowa (Anderson 1983). The landscape in the project area was primarily produced through erosion during late Wisconsinan and post-glacial times. Some valleys are extensive, resultant of glacial stream downcutting. Evidence for the accelerated downcutting is the extensive sands and gravels.

The Des Moines Lobe lacks an obscuring mantle of loess because the ice advance took place after the period of greatest Wisconsinan loess deposition in the state. The southern margins of the Des Moines Lobe are irregular in part, owing to the short duration before glacial retreat of about 1,000 years. The resultant feature is a terminal moraine called the Bemis moraine.

Streams in the area today are slow and sluggish, except during times of high water levels. Elevation of the area in general ranges from 800 to 950 feet National Geodetic Vertical Datum (NGVD). Elevation of the specific project site ranges from 800 to 820 feet NGVD.

BEDROCK

The bedrock of the project area consists of Pennsylvanian age cyclothermic sandstones, siltstones, shales, limestones, and coals, with shales as the dominant rock type. These rocks set unconformably on top of Mississippian age rocks. Bedrock is possibly assigned to formations of the Marmaton group (plate C-1). Stratigraphic determinations at Saylorville Spillway, 10 miles north, are that the bedrock is composed of Floris and Swede Hollow formations of the

Cherokee group. Regional dip of the bedrock is gradual and to the southwest. Thickness of the Pennsylvanian age rocks ranges up to 200 feet in some locations. The project site lies on the edge of the geologic structure called the Forest City Basin. The center of this structure is in southwest Iowa where the Pennsylvanian strata reach a maximum thickness of 1,700 feet and confines most of the strata to southern and western parts of the state. Depth to bedrock at the project site ranges from 7.5 to 55 feet. Clay, sand, and gravel sit atop the bedrock.

PLEISTOCENE AND HOLOCENE DEPOSITS - SOILS

The Pleistocene age deposits in the project area consist of alluvial and glacio-fluvial sands and gravels resting unconformably on Pennsylvanian age bedrock. Sitting on top of the Pleistocene sands and gravels are Holocene alluvial silts and clays. Thickness of the Pleistocene sands ranges from 4 to 41 feet, with gravels mixed in various layers up to a few feet thick. The sand deposits contain more silt or clay in the upper few feet and become increasingly cleaner in the lower deposits. Hydrologic conductivity should be higher in the cleaner sands and gravels in the lower deposits. Some of the lower sand and gravels are believed to have developed during the Aftonian Interglacial Stage of the pre-Illinoian glacial stage (plate C-1). The remaining sands and gravels are valley train deposits belonging to the Mackinaw member of the Henry formation of Wisconsinan age (Anderson 1983).

The Holocene alluvial silts and clays which sit on top of the Pleistocene sands are called the Cahokia Alluvium. Thicknesses of the Cahokia Alluvium range from 1.5 to 15.5 feet. The principle parent materials for the soils in the project area are glacial drift, loess, and alluvium. Some of the soils are covered by fill. The fill is composed of the following mixed debris: silt, clay, blacktop, cement, sand, glass, and ceramic chips. Thickness of the fill ranges from 2.5 to 17 feet where present.

MINERAL RESOURCES

Currently, the only mineral resources near the project area are sand and gravel; these will not affect the project. In the project area, coal mining was of considerable importance between 1840 and 1930. The first large coal mining operation in Iowa was located in Des Moines, south of the Raccoon River (Van Dorpe 1988). Presently, there are no coal mining operations in the area; although, some attention has been given to the fact that coal was mined on the northern end of the levee project (plate C-2). The mining operation, namely the Keystone Coal Company, terminated

their operation in 1922 (Van Dorpe 1988). The coal seam mined was found 147 feet below the surface (elevation at 660 feet NGVD). At that depth, the abandoned mine should not affect the project. Any abandoned air shafts found at the project that could lead to piping or some other problem will be filled. Presently, locations of any shafts to the surface are unknown.

SUBSURFACE EXPLORATIONS

The exploration program was divided into four phases. The purpose of the program was to define areas of generalized soil conditions, as well as areas of specific concern for structures, underseepage, slope stability, and settlement.

The phase 1 exploration program was initiated and conducted in March and April of 1965. The spacing between borings varied from 600 to 1,000 feet throughout the levee alignment. At designated areas, 3 borings were taken in section to include the existing impervious levee. The soil was penetrated by manual methods. A total of 52 borings, designated WDM-65-1 through WDM-65-52, were extended manually with 4-inch Iwan augers from 4 to 22 feet to determine alignment evaluation. Auger sampling methods were employed to obtain jar samples of the impervious top stratum at 2-foot intervals both above and below groundwater level. Below groundwater level and beneath the impervious top stratum, holes were extended into the pervious substratum by pushing a 2-inch diameter thin-walled conduit. Hole extensions ranged from 1 to 7 feet. Jar samples of soil representing each strata change were obtained. Locations of the hand auger holes are shown on plates 4 through 22, 24, and 27 of the main report. Logs of borings are displayed in sequence on plates 29 through 34 of the main report. Geologic profiles depicting hand auger borings (labeled by number) obtained by CENCR-ED-G along the proposed levee alignment and one drill boring (labeled by letter) obtained by a private firm in the vicinity of the proposed levee alignment are shown on plate C-3.

In addition to the phase 1 exploration program, private firms were contacted for further soils information. Additional subsurface information was obtained from Patzig Testing Laboratories Co., Inc., Des Moines, Iowa; West Des Moines Water Works, City of West Des Moines, Iowa; and Martin Marietta Aggregates, West Des Moines, Iowa. Explorations from each source were conducted from March 1968 to April 1987, March 1988, and from 1944 to 1945, respectively.

The subsurface soil explored by the above firms was penetrated by rotary drilling methods. Hollow stem and continuous flight augers were used to extend the holes.

Standard split spoon and shelby tube sampling methods were employed to obtain samples at 5-foot intervals. Standard "N" penetration (blows per foot of a 140-pound hammer falling 30 inches on a 2-inch O.D. split spoon) were taken at each interval depth. Boring logs for the sources mentioned are not presented. However, the exploratory information was examined and evaluated to determine the subsurface stratigraphy to and into bedrock and to locate the areas and extent of landfill above natural ground surface.

Following this sequence of events, a site inspection was conducted in April of 1988 to examine the proposed and alternate flood protection alignment, except for the portion along Jordan Creek. Upon completion of the inspection and in conjunction with the existing explorations, it was determined that additional explorations were necessary. A more intensive site inspection by Geotechnical Branch personnel was undertaken to explore selected levee and flood wall alignments. The purpose for this inspection was to document geotechnical features and to lay out supplementary subsurface explorations, both shallow and deep. Shallow borings extended 10 to 30 feet through encountered landfill and through impervious top stratum to a depth of at least 5 feet into the underlying pervious substratum. Deep borings extended 50 to 60 feet through encountered landfill and through both the impervious top stratum and pervious substratum to a minimum depth of 5 feet into the underlying bedrock.

The phase 2 exploration program was initiated 13 September 1989 with a 2 day site inspection. Personnel representing expertise in geotechnical, structures, and project engineering were in attendance. The entire levee/flood wall alignment and proposed borrow areas were traversed. Time was allotted to investigate sites involving specific flood control structures, i.e., flood walls, flood gates, gatewells, etc., and areas of concern for underseepage, settlement, and slope stability. Explorations pertinent to the investigation were determined, staked, and flagged for drilling. Particular attention was paid to drill rig access. It was determined that the explorations could be accomplished by either a truck-mounted or an all-terrain rotary drill rig.

Upon return to the district office, a detailed exploration program was prepared by the Geotechnical Branch technical contributor. This program expressed the exploratory drilling requirements for each proposed boring. Location, termination depth, estimated depth, and purpose for each boring is tabulated on plate C-4.

On 21 September 1989, geotechnical personnel again inspected the alignment. The purpose for this visit was to present

the exploration program (plate C-4) to the drilling supervisor, to acquaint him with the drill hole locations, and to inform him of the purpose and extent of each drill hole. Drilling commenced 25 September 1989 and was completed 12 October 1989. A CME-55 rotary drill rig mounted on a steel track all-terrain vehicle (ATV) Bombardier Muskeg Carrier was transported to the site to accomplish the drilling. This rig was selected due to its relatively low ground pressures (1.36 psi unloaded and 3.07 psi loaded). The drilling was accomplished by government contract with INDECO of Iowa, Inc., Bettendorf, Iowa. A total of 117 hours of drilling time was expended to accomplish the work.

The exploration program was broken into two specific drill boring groups, red borings and blue borings (plate C-4). Red borings were designated specifically for structures, levee, and ponding areas. Structures include railroad closure gates, road closures, concrete flood I-walls, gatewells, and pump stations. Structure borings were to be taken through the impervious top stratum clay and pervious substratum sand 5 feet into bedrock, either by coring or, if feasible, split spooning for the purpose of determining underseepage and settlement concerns. Location was dependent on where the structure was to be built. Anticipated depths were estimated; they extended to as much as 55 feet. Levee borings were to be taken through the impervious top stratum clay to a depth of 20 feet or 5 feet into the pervious substratum sand for the purpose of underseepage, settlement, and slope stability concerns. One levee boring was to be extended into bedrock for underseepage concern. These borings were spaced strategically to supplement previous hand auger borings. Where trash dump and garbage dump landfills were encountered, these borings were to penetrate the extent of these landfills, particularly for settlement concerns. Pond borings were to be taken through the impervious top stratum clay at two designated borrow/ponding areas to a depth of 15 feet for the purpose of determining suitable borrow for levee construction. A third ponding area was to be explored through an unknown thickness of concrete waste into the pervious substratum sand to a depth of 20 feet for the purpose of determining if the site is feasible to construct. Blue borings were designated specifically for levees that were to be taken 15 to 30 feet in depth for the purpose of underseepage, settlement, and slope stability. Each boring was to extend through the impervious top stratum clay and 5 feet into the pervious substratum sand. One boring was anticipated to penetrate landfill, and another was to penetrate the existing impervious embankment. Spacing was once again strategically placed to supplement previous hand auger borings.

The soil was penetrated by the ATV rotary drill rig stated above. Six-inch hollow stem augers were used to extend most holes. Six borings necessitated the use of bentonite drilling fluid to advance the hole. Standard split spoon sampling methods were employed to obtain jar samples at every 2.5-foot interval depth through the impervious top stratum clay, 5-foot interval depth through the pervious substratum sand, and 2.5-foot interval depth into moderately hard to moderately soft bedrock shale. Standard "N" penetration (blows per foot of a 140-pound hammer falling 30 inches on a 2-inch O.D. split spoon) were also taken at interval depths of 2.5 feet (impervious top stratum clay), 5 feet (pervious substratum sand), and 2.5 feet (soft bedrock shale). Pocket penetrometer tests were recorded in each split spoon sample of the impervious top stratum clay. Blow counts were recorded at each 6-inch interval. Samples were surface cleaned prior to placement into wide mouth glass jars for transportation to the district laboratory for classification and testing. Six-inch hollow stem augers were used to sample every 2-foot interval depth through the impervious top stratum clay to obtain bag samples of various strata in both the 59th Street and Valley Drive and the Fuller Road borrow ponding areas. Bag samples of not less than 30 pounds were collected for each impervious top stratum clay soil type; samples generally represented each 5-foot thickness of extended depth. A total of 36 borings were completed. All red and blue borings were designated WDM-89-53 through WDM-89-88. The borings varied in depth from 15.0 feet to 50.5 feet. Locations of the mechanical holes are shown on plates 4 through 22, 24, and 27 of the main report. Logs of borings are displayed in sequence on plates 29 through 34 of the main report. During the exploration program, the Geotechnical Branch primary technical study team member spent 2 days on site beginning 27 September 1989. The purpose of the visit was to observe drilling and sampling operations for compliance with the exploration program's purpose and needs and to examine first hand the subsurface soils (top stratum clay, substratum sand, and bedrock).

The phase 3 exploration program initiated from a 2 day general design conference held in West Des Moines, Iowa on 20-21 November 1989. The conference was attended by technical engineering personnel from the Office Chief of Engineers, North Central Division, and Rock Island District. During this conference, concern was addressed to the landfill areas as to their contents and extent. Following discussions, several areas of concern were again inspected by RID personnel. The garbage dump landfill site was determined to be the center of attention. Concern for other areas of landfill were also inspected. Each area was examined and discussed for the effects it would have on the levee construction. At this time, it was determined that the best way to view the garbage dump landfill was to

excavate inspection trenches. Coordination for this scheme was initiated following the return to the district office. On 12 December 1989, the backhoe operations were initiated. A John Deere Model 210C Series 1 backhoe was put into operation by the City of West Des Moines maintenance department. Two test pits were excavated to 20 feet in length, 3 feet in width, and 11 feet in depth. Materials were examined on site. Each test pit revealed a 4- to 5-foot impervious cap over miscellaneous landfill that extended to the full excavated depth of the pit. Due to unknown contaminates, samples were not taken and retained from the test pits.

The phase 4 exploration program will commence in the future, prior to plans and specifications. At this time, 23 exploratory borings will be taken to close all exploration gaps of the project. These holes were not drilled during the primary phase 2 exploration program due to access difficulties, alignment changes, and funding. This decision was made during the 13-14 September 1989 site inspection which eliminated 4 drill holes, added 4 drill holes, and left 19 drill holes as planned. These holes again were designated as red and blue borings. The remaining 9 red borings of which 7 are designated structure borings were postponed for mechanical drilling until the levee alignment is firm. Due to access problems for the drill rig, 2 red holes (one levee and one ponding area borrow) were postponed and will be manually augered in lieu of mechanical drilling. The remaining 10 blue holes, designated as levee borings, are postponed for mechanical drilling. This resulted generally from access (remote, difficult, or not any), undetermined alignment, excessive vegetation, or private property not included in the project. These borings will be manually drilled by hand auger in lieu of mechanical drilling. During this phase of exploratory drilling, selected sites will be determined for undisturbed sampling. The intent of this will be to obtain samples suitable for verifying shear strength parameters.

SOIL TESTS

Laboratory soil testing was performed by the CENCR-ED-G laboratory on soils obtained manually in March and April 1965 and mechanically in September and October 1989.

Soils sampled in 1965 were obtained manually with an Iwan auger. Each sample was visually classified. Natural moisture contents (240 tests) were determined on each sample of impervious top stratum. Five Atterberg limits tests were run on selected impervious soils; the results are shown on the plasticity chart, plate C-5. Visual field and laboratory classifications and indicated values for natural

moisture content and Atterberg limits are shown on logs of borings, plates 29 through 34 of the main report.

Soils sampled in 1989 were obtained mechanically with a standard 2-inch split spoon. Hollow stem augers and bentonite drilling fluid were used to advance the borings to sampling depths. Blow counts were recorded for each standard 2-inch split spoon penetration performed in the impervious top stratum (Cahokia alluvium), pervious substratum (Henry formation sand), and bedrock (Pennsylvanian shale). Eighty-four picket penetrometer tests were performed in the field on the impervious top stratum; three were performed on the existing levee embankment. Visual classification was performed on each soil sample. Natural moisture content was determined on impervious soils (187 tests) and bedrock shales (10 tests). Twenty-three Atterberg limit tests were run on selected representative samples of the impervious top stratum; the results are shown on the plasticity chart, plate C-6. Thirty-four minus No. 200 sieve wash tests were performed on representative samples of the pervious substratum. Full gradation tests were performed on 32 of the wash tests. Effective grain size (D_{10}) and percent passing the No. 200 sieve was determined for each gradation and wash test, respectively. Gradation curves are shown on plates C-7 through C-38. Visual field/laboratory classifications; recordings for standard split spoon penetration blow count and pocket penetrometer; and indicated values for natural moisture content, Atterberg limits, minus No. 200 sieve wash, and effective grain size (D_{10}) are shown on logs of borings, plates 29 through 34 of the main report. Undisturbed shear strength testing will be accomplished by Division laboratories prior to plans and specifications to ensure shear strength parameters are met or exceeded. Samples for this testing will be accomplished during the phase 4 exploratory drilling program.

PROPOSED EMBANKMENTS

Presently, levees exist in some reaches along the proposed alignment. These levees now provide limited flood protection. The existing levees, built by the city of Des Moines, Iowa prior to 1965, have provided satisfactory performance and prevention of low level flooding over their years of existence. These levees lack a tie-off to high ground. Recent floods on Walnut Creek have demonstrated that the interior area experiences some flooding due to water getting around this line of protection. Inspection of these levees in April 1988 revealed that maintenance to the levees has been neglected over this period of time. Vegetation, brush, and trees have grown unobstructed. The trees have grown to enormous size in both height and diameter. The root systems have totally impregnated the embankment. The existing condition of these levees offers no alternatives to tie into them and provide a safe long-lasting structure. The project plan is to degrade them in preparation for construction of

new levees. When degraded, brush and vegetation will either be pushed aside to remain on-site or will be removed, hauled, and placed in acceptable landfill areas. Materials from the existing levees will be reused in new construction. The existing levees are composed of area top stratum soils. Inspection trenches beneath these levees are non-existent. Although subsurface soils beneath these existing levees appear suitable, the knowledge of buried pipes is unknown.

Two types of flood protection considered for this project are levee embankments and concrete floodwalls (I-wall type).

The first type of flood protection entails construction of new levee embankments. Impervious clay will be hauled to the construction site. Material will then be moved and placed by scrapers and spread by bulldozers. Supplemental material, if needed, will come from a remote privately-owned 30-acre hilltop borrow site located at south 50th Street and Grand Avenue in West Des Moines, Iowa. Some 20 to 50 feet of material above the surrounding grade is available on the north side of Grand Avenue. On-site material will come from degrading of existing levees and from two floodplain borrow/ponding areas. The levees will be constructed by semi-compacted methods to oblige any less than optimum borrow soils. The slopes will be constructed to 1V on 3H riverside and 1V on 3H landside to harmonize urban space limitations and to provide stability to the structure. The crown of the levee will have a minimum width of ten feet to serve normal maintenance and emergency flood-fighting operations. Where variable subsurface conditions exist in the form of landfill, the standard levee design will be altered to compliment the condition. Typical levee sections incorporating each variable construction condition are shown on plate C-39 and plate 23 of the main report.

An exploration (inspection) trench will be excavated under all levees. A conventional approach will be implemented throughout the project where innovative methods may not be effective. A standard inspection trench located at or near the centerline of the levees will be used where subsurface conditions consist totally of impervious top stratum Cahokia alluvium, on Hoak Drive where the existing gravel roadbed will be removed, and parallel to Walnut Creek where the existing levee is intended to be degraded. An expanded inspection trench located either at or near the centerline or at the waterside toe of the hauled fill levees will be used where landfill of variable depth exists. Where effective results can be achieved by innovative methods, a narrow vertical inspection trench will replace the proposed standard or expanded inspection trenches. Design concepts of these trenches, shown on typical levee sections plate C-39 and plate 23 of the main report, incorporate each variation.

The second type of flood protection is construction of concrete floodwalls (I-wall type) on the east side of 63rd Street paralleling Walnut Creek.

As revealed on the geologic profile, plate C-3, the new levee embankments will attain heights from 2 to 13 feet. Isolated areas indicate that levee heights extend even greater, to as much as 18 to 20 feet, for short reaches crossing ditches. Ground surface irregularities beneath the structure will be filled and compacted with impervious material. Depressions and sloughs landward of the embankments will be filled with sand up to the natural ground surface for 100 feet beyond the levee toe or berm. This will establish ground surface uniformity and prevent the occurrence of unrestricted underseepage. Reaches of levee embankment requiring a landside sand seepage berm to protect against excessive underseepage are shown on plates C-66 through C-75.

The new levee embankments will be constructed entirely of selected impervious fill materials. Materials excavated to predetermined depths from borrow area D (59th Street and Valley Drive), classified as CL-CH, will be used where designated. Materials excavated to predetermined depths from borrow area A (Fuller Road), classified as CH, will also be used where designated. Additional borrow below the predetermined excavation depths at each of the stated sites is available, if necessary. These materials from both sites are classified as CL-CH. Additional material, if needed, will be attained from the Grand Avenue site; the material is classified as SC, CL, and CL-CH and deemed impervious. The SC soils will require no less than 35 percent by weight passing the No. 200 sieve. Moisture control for the impervious fill will be monitored by on-site construction inspections. For the anticipated CL-CH borrow material at borrow area D (59th Street and Valley Drive), a deviation of no more than 2.0 percent dry and 4.5 percent wet of optimum moisture content is desired. This soil with a natural moisture content of less than 1 percent dry of optimum will not require conditioning prior to placement. For the anticipated CH borrow material at borrow area A (Fuller Road), a deviation of no more than 2.5 percent dry and 5 percent wet of optimum moisture content is desired. This soil with a natural moisture content of less than 2 percent wet of optimum will also not require conditioning prior to placement. Deviation control at the remote Grand Avenue borrow site will be determined during construction, if used. Compaction curves of borrow area D and borrow area A are shown on plates C-40 through C-44. The moisture control evaluation summary revealing allowable deviation from optimum moisture content for each soil type is shown on plate C-45.

Construction of the embankment by semi-compacted methods will be controlled in two ways: (a) uncompacted lift thickness (not more than 9 inches with tamping-type roller and 12 inches with rubber-tired roller) and (b) specified maximum dry density. A minimum of 95 percent of maximum dry density will be specified for each lift of impervious fill. Both tamping-type (tractor-drawn and self-propelled) rollers and rubber-tired rollers will be specified to accomplish this requirement. Either tractor-drawn and/or self-propelled tamping rollers will be permissible. Both contractor quality control (CQC) and government quality assurance (QA) testing will serve to assure that required maximum dry density is achieved during construction. Initially, the designated rate of testing for CQC will be 4 field in-place density tests (ASTM-D 1556 sand cone and/or ASTM-D 2167 rubber balloon) for every 10,000 cubic yards of fill placed or for at least one test per day that embankment operations are performed. QA testing will supplement these requirements. The increased rate of CQC testing will continue until the construction operation can be deemed successful to accomplish the proposed requirements. It will then be reduced to one field in-place density test for every 10,000 cubic yards of fill placed (minimum one test per day during embankment placement). As a density supplement to the standard tests stated, the contractor may use a nuclear device conforming to ASTM-D 2922 standards. The devices use as a moisture supplement conforming to ASTM-D 3017 standards will be discouraged without sufficient and regular moisture correlation tests. The nuclear device data will not be allowed to supplement required standard testing data. Moisture control will not pose a problem since natural moisture contents of the borrow sources are within acceptable moisture deviation ranges. Any materials encountered that become too wet or too dry for proper compaction will require that the contractor either dry-back or pre-wet the material prior to rolling operations.

FOUNDATIONS FOR EMBANKMENTS

The entire foundation beneath the new levee embankments will be cleared, grubbed, and stripped to remove unsuitable matter. Inspection trenches will be necessary beneath all levee embankments. The trenches will be located at or near the centerline or at the riverward toe of the proposed embankment. Trench excavations are not expected to penetrate normal groundwater levels. Standard inspection trenches for the new levees will be 8 feet wide to accommodate modern construction equipment. For embankment heights greater than 6 feet, the trenches will be extended to a maximum depth of 6 feet to unveil any significant underground features such as pipes or unsuitable materials. These unsuitable materials will be penetrated to preclude the possible occurrence of serious shallow seepage. Soft

foundation materials within the levee foundation extremities at or near the surface will be excavated. For embankments less than 6 feet in height, the trenches will extend to a maximum depth equal to the embankment height. Side slopes for the trenches will be 1V on 1H. Where extensive landfill exists, flatter slopes of up to 1V on 3H will be used. The trenches will be backfilled with impervious fill compacted to embankment standards. In areas of existing landfill, excavations for expanded inspection trenches will extend through the landfill to at least 1-foot into the underlying Cahokia alluvium impervious top stratum, if existing. This will provide a positive cutoff (impervious barrier) to prevent the potential occurrence of shallow seepage through the landfill. Details and locations of the trenches are shown on plate C-39 and plate 23 of the main report.

In landfill areas, standard inspection trenches will be expanded to incorporate various schemes to compliment the variable thickness. Where the landfill areas are 5 feet or less in thickness, excavation will encompass the entire base width of the levee. Excavated landfill will be reused or wasted. Beneath the embankment, the excavation will be backfilled with semi-compacted impervious fill; outside the structure will be random fill. In landfill areas 10 feet or less in thickness, the excavation will form a trench with 1V on 1.5H side slopes and a 10-foot bottom width. Landfill will be reused or wasted, and the trench will be backfilled with semi-compacted impervious fill. For landfill areas 20 feet or less in thickness, the excavated trench will be offset from the riverside slope of the levee embankment. Beneath the levee, the side slopes will be 1V on 3H, whereas riverward will be 1V on 1H. The bottom width will be 15 feet. The 15-foot trench width beneath the levee will be backfilled with semi-compacted impervious fill; the remaining excavation with random backfill. The landfill will be reused or wasted. Design concepts pertinent to these subsurface conditions are shown on typical levee sections, plate C-39.

An innovative supplement to both the standard and expanded inspection trenches proposed for this project to unveil underground pipes and unsuitable materials will be to use a vertical inspection trench to excavate where shallow seepage can effectively be reduced or eliminated. The trenches will be located at the riverside toe of the prcposed embankment. The trenches will be no less than 1 to 2 feet in width. The trenches will extend at least 1-foot into the existing Cahokia. This scheme can be used for all embankment heights from 2 to 13 feet, if deemed suitable. Trenches will be backfilled with a blend of sand and bentonite and capped with a 3- to 4-foot thickness of clay. Both the blended materials and the clay cap will be compacted to insure consolidation of both materials. The trench can be straddled to achieve compaction. Specifications will

require that the blended sand-bentonite and clay cap will be placed in 4-inch thick uncompacted lifts, and then compacted to 95 percent of maximum dry density utilizing hand-operated powered tampers. The clay cap backfill will be placed on the wet side of optimum moisture content and within the allowable deviation from the optimum moisture content. By this method, the blended backfill will attract moisture from the clay cap and form a more permanent bond between the two materials; thereby, the possibility of a gap forming is eliminated. Recent excavations at Lockport Approach Dike revealed that a positive contact in the form of interlocking had been achieved between the clay cap and the blended backfill; no bridging had occurred. In this case, the blended backfill had been placed by dumping, spreading, and tracking the surface of each lift with a dozer. Prior to blending, the sand shall be dried in driers at a batch plant to either a saturated surface dry or drier condition. The sand will be clean free draining with less than 5 percent passing the No. 200 sieve. Granular bentonite, 10 percent by weight, will be blended with the sand for use in dry excavated trenches. Where groundwater is unexpectedly encountered in excavated trenches, the blended backfill will incorporate the use of dried and crushed bentonite in lieu of granular. A 20 percent by weight blend will be used for the dried and crushed bentonite in lieu of 10 percent for the granular. This blend will allow placement under water without premature swelling of the bentonite. This scheme will also provide a positive cutoff (impervious barrier) to prevent the potential occurrence of shallow seepage through the landfill. The proposed blend of sand and bentonite backfill has been used at the Rock Island District since 1950 to provide impervious seals in various instrumentation installations to deter the infiltration of groundwater; no deterioration in imperviousness has been documented. More recently in 1987, a large impervious cutoff trench seal was installed in the Chicago Sanitary and Ship Canal - West Embankment dike (Lockport Approach Dike) to prevent ongoing through seepage and subsidence. The blend was composed of granular bentonite (10 percent by weight) and sand (saturated surface dry or drier). Excellent success has been documented thus far. Both Waterways Experiment Station (WES) and Memphis District soils and geotechnical branches indicated support of the sand-bentonite cutoff. WES has performed model studies to show that a sand-bentonite backfill placed under dry conditions would not produce excessive swelling and would support a roadway. It was necessary to protect the backfill with an impervious cap of sufficient thickness. Testing revealed the shear strength of the sand-bentonite was equivalent to the shear strength of the compacted backfill. Memphis performed model studies to show a 1-foot thick blanket composed of a 6 to 8 percent blend of bentonite to sand provided a positive cutoff seepage barrier if compacted sufficiently. Shear tests indicated that the variance of phi values was no more than 2

degrees. Permeability tests produced a permeability of $k=10^{-7}$ cm/sec. Model testing by the Rock Island District in the 1970's confirmed that a confined barrier of blended sand-bentonite (10 percent bentonite by weight) of limited thickness and placed in the dry provided a positive seepage cutoff. Details and locations of the trenches are shown on plate C-39.

Boring logs indicate that the natural top stratum is composed of impervious Cahokia alluvium (CL, CL-CH, and CH soils). In addition, isolated patches of SP, SP-SC, and SC soils, insignificant in extent, are found within the area top stratum. In some reaches, the Cahokia alluvium has been partially or totally removed and replaced by landfill. In other reaches, the landfill has been placed on top of the existing Cahokia alluvium. In most cases, the landfill is impervious CL soils. Other cases reveal semi-impervious (SC soils) to pervious (SP soils) fill in addition to road stone and concrete waste. Some of this landfill contains voids of various sizes. Debris appears to be a common ingredient for much of the landfill (plate C-46). The Cahokia alluvium extends some 3 to 23 feet beneath the natural ground surface. This stratum thickness contains isolated thin layers of SP soils from 2 to 4 feet thick sandwiched within the Cahokia alluvium (plate C-46). Moisture contents of the Cahokia alluvium top stratum range from 10 to 40 percent for CL soils, 18 to 46 percent for CL-CH soils, and 18 to 59 percent for CH soils (plate C-47). Atterberg limits for these soils are shown on plates C-5 and C-6. A tabulation (plate C-48) and plot (plate C-49) of Atterberg limits and moisture content indicates that no exceptionally weak or sensitive soils were encountered and that shear strength is high. Standard penetration tests for the Cahokia alluvium range from 2 to 16 for CL soils, indicating a soft to stiff consistency; 6 to 15 for CL-CH soils, indicating a firm to stiff consistency; and 3 to 15 for CH soils, indicating a soft to stiff consistency (plate C-50). Isolated standard penetration tests (2 tests of CL soils and 1 test of CH soils) indicated unusually high values and were not included in the consistency evaluation above. Groundwater is confined within the boundaries of the Cahokia. Recordings obtained in 1965 indicate the level to be 1 to 11 feet below the existing ground surface with an average depth of 5.3 feet. Recordings obtained in 1989 indicate levels to be 8 to 18 feet beneath the existing ground surface with an average depth of 11.8 feet. No major flooding event was recorded in 1965. It is suspected that the significant differences in levels are due to a 2 year drought and/or to the period of the year, April for 1965 versus October for 1989.

Undisturbed shear strength correlation curves plotting cohesive shear strength versus water content for CL, CL-CH, and CH soils are shown on plates C-51 through C-53,

respectively. The curves were developed by the Missouri River Division from unconsolidated-undrained quick triaxial and unconfined compression tests supplied by the Rock Island District and are applicable to the Raccoon River alluvial soils. A summary plot of these soils is shown on plate C-54. The CL soils curve indicates a range in cohesion from 280 to 750 pounds per square foot (psf) with moisture contents varying from 10 to 40 percent (plate C-47); the average cohesion exceeds 500 psf (plate C-55). The CL-CH soils curve indicates a range in cohesion from 230 to 780 psf, with moisture contents varying from 18 to 46 percent (plate C-47); the average cohesion exceeds 600 psf (plate C-55). The CH soils curve indicates a range in cohesion from 380 to more than 740 psf, with moisture contents varying from 18 to 59 percent (plate C-47); the average cohesion exceeds 700 psf (plate C-55). Occasional borings of CL soils and several borings of both CL-CH and CH soils indicate shear strengths exceeding 1,000 psf; these were not included in the ranges.

Pocket penetrometer tests were performed on the Cahokia alluvium during the exploration program to determine the unconfined compressive strength of the soils in tons per square foot (tsf) (plate C-56). Resulting readings were converte to cohesive shear strength (plate C-56). A plot of CL soils was made comparing penetrometer shear strength with moisture content correlation shear strength. In general, the resulting plot trends (plate C-57) indicate that the pocket penetrometer average cohesive shear strength exceeds the moisture content correlation average shear strength by a factor of 2. Plots of both CL-CH and CH soils (plate C-57) also indicates similar results.

The pervious substratum (Henry formation) lies directly beneath the Cahokia top stratum and consists of SP-SC and SP soils. The SP-SC soils generally overlies the SP soils. The substratum was penetrated 1 to 7 feet manually in 1965 and 1 to 35 feet mechanically in 1989 by CENCR-ED-G forces (plate C-46). Private firms extended 1 to 33 feet mechanically. Standard penetration tests, obtained by private firms in the general vicinity of the alignment, ranged from 2 blows per foot to more than 54 blows per foot and indicates a very loose to a very dense relative density. Standard penetration tests (SPT) obtained by CENCR-ED-G along the proposed alignment ranged from 3 to 28 blows per foot (plate C-58). These values indicate a very loose to medium dense relative density for the SP-SC soils and a loose to medium dense relative density for the SP soils (plate C-58). Isolated SPT (2 tests) indicated unusually high values and were not included in the relative density evaluation above. Logs of borings reveal these values as shown on plates 29 through 34 of the main report. The upper portion of the pervious substratum is dirty (between 5 and 12 percent passing the No. 200 sieve) as opposed to the

clean (less than 5 percent passing the No. 200 sieve) lower portion. The pervious substratum consists of a variable depth of alluvial sand overlying glacial-fluvial sand. The depth of the pervious aquifer varies from 2 to 35 feet. Gradation tests reveal the effective grain size (D_{10}) range from 0.10 to 0.40 mm for the SP-SC soils and 0.18 to 0.38 mm for the SP soils (plate C-59). The coefficient of permeability (k_h) ranges from 0.02 to 0.28 centimeters per second for the alluvial and glacial-fluvial sands (plate C-59).

Bedrock in the form of Pennsylvanian shale was encountered by other firms ranging from elevations 762 to 769 feet NGVD. One occurrence found a bed of sandstone and shale some 12 feet thick overlying the bedrock shale. At the upper end of Walnut Creek, bedrock was found to be at elevation 789 feet NGVD. Bedrock consisting of Pennsylvanian age cyclothermic shale was encountered by CENCR-ED-G. The bedrock surface was found to vary (plate C-46). At the upper end of the project along Walnut Creek, the bedrock surface was at elevation 776 and dropped to elevation 766 midway along Walnut Creek. Nearest to the downstream portion of the Raccoon River, where the alignment is closest to the river, the bedrock surface ranged from elevation 770 to 759 in an upstream direction. In the area of the sand pits, where the Raccoon River is farthest away, the bedrock surface rises significantly to elevation 793. At the lower end of the project at the junction of Jordan Creek, the bedrock surface is again lower at elevation 775. The shale was penetrated by standard split spoon to obtain a sample. Standard penetration tests from 51 to 112 indicate the shale to be moderately soft to moderately hard (plate C-60).

FOUNDATION FOR OTHER STRUCTURES

A variety of foundation materials was encountered during exploratory operations (plates 4 through 22, 24, 27, and 29 through 34 of the main report). Unsuitable materials in the form of landfill and or soft Cahokia alluvium encountered at specific structure locations will be removed and replaced with suitable material. The replacement materials will be compacted to obtain densities equal to or greater than adjacent undisturbed foundation material. Suitable materials encountered were decided from field and laboratory examination. In the field, material suitability as structural support was determined during exploratory operations by correlating consistency and relative density with standard penetration tests, pocket penetrometer tests, and relative unconfined compressive strength. In the geotechnical laboratory, material suitability as structural support was determined by correlating cohesive shear strength for the Cahokia soils with moisture content tests, and from effective grain size and relative coefficient of

permeability for Henry soils, and from classification tests of both Cahokia and Henry soils. Reference to these results are tabulated on plates C-47, C-50, C-56, C-58, and C-59 for each exploratory boring relative to proposed specific structures and their location. The remaining proposed structures were not explored at this time but were planned prior to plans and specifications.

Existing subsurface soils at the proposed main line and side track double swing gate closure (station 220+00) across the Norfolk and Southern Railroad along Walnut Creek (reference boring WDM-89-54, plates 22 and 33 of the main report) appear suitable to support the structure. The Cahokia CL and CL-CH soils indicate firm to stiff clay (elevation 819 to 799) with indicated cohesive shear strength ranging from 470 to 700 psf and greater. Underlying this is medium dense sand to elevation 780. A 3-foot thick strata of soft clay exists from elevation 808 to 805. A 4-foot thick strata (elevation 780 to 776) sits atop the bedrock shale surface (elevation 776); bedrock was penetrated 5.8 feet in depth.

Existing subsurface soils at the proposed single-lane swing gate closure (station 218+00) across the Wheeler Lumber Corp. yard along Walnut Creek (reference boring WDM-89-55, plates 22 and 33 of the main report) indicates marginal structure support in the Cahokia. The clay CL soils indicate a soft consistency, whereas the CL-CH soils are stiff (elevation 818 to 804). Indicated cohesive shear strength ranges from 340 to 520 psf and greater. A cohesive transition zone lies directly beneath elevation 804 and consists of SC soils which indicates stiff to very stiff consistency (elevation 804 to 795). Below this, a medium dense to dense sand exists from elevation 795 to 775. The bedrock shale surface exists at elevation 775; bedrock was penetrated 3.1 feet in depth.

Existing subsurface soils at the proposed two-lane tilt-up panels closure (station 192+71) across 63rd Street, north of Ashworth Road, and adjacent to Midland Brick along Walnut Creek (reference boring WDM-89-59, plates 19 and 33 of the main report) indicate suitable support for the structure. Firm clay (elevation 812 to 805) with indicated cohesive shear strength ranging from 470 to 560 psf and greater overlies loose to medium dense sand (elevation 805 to 792). A 4-foot thick strata of very soft SC soils exists on the surface (elevation 816 to 812) and should be removed. A thin strata of very loose material exists directly beneath the water level (elevation 803 to 802) in the sand. Beneath the sand, a lower substratum of firm clay (elevation 792 to 773) sits atop the bedrock shale surface (elevation 773); bedrock was penetrated 3.3 feet in depth.

Existing subsurface soils at the proposed double track swing gate closure (station 189+46) across the Norfolk and

Southern Railroad on the west side of 63rd Street between Grand Avenue and Ashworth Road along Walnut Creek (reference boring WDM-89-59, plates 19 and 33 of the main report) appear suitable to support the structure. Firm Cahokia CL soils (elevation 812 to 805) with indicated cohesive shear strength ranging from 470 to 560 psf and greater overlies loose to medium dense sand (elevation 805 to 792). A 4-foot thick strata of very soft SC soils exists on the surface (elevation 816 to 812) and should be removed. A thin strata of very loose material exists directly beneath the water level (elevation 803 to 802) in the sand. Beneath the sand, a lower substratum of firm clay (elevation 792 to 773) sits atop the bedrock shale surface (elevation 773); bedrock was penetrated 3.3 feet in depth.

At the proposed pump station with interceptor forebay and gatewell (station 187+50) at Val Air Lanes (reference boring WDM-89-58, plates 19 and 33 of the main report), the landfill and Cahokia materials are marginal for structural support. Landfill (elevation 814 to 807) in the form of CL soils is soft to firm in consistency and may require removal. Cahokia CL soils beneath the landfill (elevation 807 to 802) indicates a soft consistency and a cohesive shear strength ranging from 360 to 420 psf that may require removal. Beneath this, the substratum sand (elevation 802 to 776) indicates a loose to medium dense relative density throughout, except for the surficial 2.5 feet showing a very loose condition. A thin 3-foot thick layer of clay beneath the sand sits atop the bedrock shale surface (elevation 773); bedrock was penetrated 2 feet in depth.

Existing subsurface soils at the proposed double leaf or roller caboose closure (station 184+61) across Grand Avenue on the east side of 63rd Street along Walnut Creek (reference boring WDM-89-60, plates 18 and 32 of the main report) indicate suitable support for the structure. The Cahokia clay CL soils are firm to stiff (elevation 817 to 799) with indicated cohesive shear strengths ranging from 420 to 750 psf. Beneath this lies very loose to loose sand (elevation 799 to 791).

Existing subsurface soils at the proposed gatewell (station 147+05) west of Valley Drive along Walnut Creek (reference boring WDM-89-66, plates 16 and 32 of the main report) indicate suitable support for the structure. The Cahokia clay CL soils are of stiff consistency (elevation 807 to 792) with indicated cohesive shear strengths ranging from 420 to 560 psf. Subsurface sand encountered at elevation 792 was penetrated 8 feet in depth.

Existing subsurface soils at the proposed gatewell (station 116+21) paralleling the north side of the Chicago and Northwestern Railroad along Raccoon River (reference borings WDM-65-30 and WDM-65-31, plates 13 and 31 of the main

report) indicate suitable support for the structure. The Cahokia CL soils are of firm to stiff consistency (elevation 803 to 799) with indicated cohesive shear strengths ranging from 390 to 420 psf. Subsurface sand encountered at elevation 799 was extended to as much as 8 feet in depth.

Existing subsurface soils at the proposed gatewell (station 104+22) paralleling the north side of the Chicago and Northwestern Railroad near the closure structure along Raccoon River (reference boring WDM-89-70, plates 12 and 31 of the main report) indicate suitable support for the structure. The Cahokia CL soils are of firm to stiff consistency (elevation 813 to 799) with indicated cohesive shear strength ranging from 480 to 540 psf and greater. The upper 2 feet is CL landfill. Subsurface sand encountered at elevation 799 was penetrated some 29 feet in depth to bedrock.

Existing subsurface soils at the proposed double track swing gate closure (station 103+57) across the Chicago and Northwestern Railroad along Raccoon River (reference boring WDM-89-70, plates 12 and 31 of the main report) indicate marginal support for the structure. Here, the structure will be supported by steel H-piles. The Cahokia CL soils are of firm to stiff consistency (elevation 813 to 799) with indicated cohesive shear strength ranging from 480 to 540 psf and greater. The surficial 2 feet of this strata is CL landfill. Underlying the Cahokia is the Henry sand (elevation 799 to 770) lying in a loose to medium dense relative density. The sand sits atop the bedrock shale surface (elevation 770); bedrock was penetrated 4.5 feet in depth.

Existing subsurface soils at the proposed sandbag closure (station 89+76) across 63rd Street along Raccoon River (reference boring WDM-89-69, plates 11 and 31 of the main report) appear to be suitable landfill soils to support the structure. Some 18 feet of this CL soils landfill (elevation 816 to 798) overlies 3 feet of stiff SC soils. The landfill indicates a stiff consistency. Subsurface sand was encountered and penetrated 1-foot, beginning at elevation 795.

Existing subsurface soils at the proposed pump station with gate well (station 81+50) west of Johnny's Vet's Club along the Raccoon River (reference boring WDM-89-72, plates 10 and 30 of the main report) indicate suitable support for the structure. The Cahokia CL soils are of soft to stiff consistency (elevation 807 to 794) with indicated cohesive shear strength ranging from 400 to 480 psf. Underlying the Cahokia is the Henry sand (elevation 794 to 759) existing in a loose to medium dense relative density. Bedrock shale was encountered at elevation 759 and penetrated 2.5 feet in depth. Adjacent to the structure, the ponding area

excavation will encounter an excessive depth (20 feet) of landfill in the form of concrete waste (reference boring 71, plates 10 and 30 of the main report). The waste area was developed from use as a ready mix truck washout. Considerable difficulty was experienced during the exploratory program. This material may require blasting to excavate the area for ponding.

Existing subsurface soils at the proposed gatewell (station 67+65) south of Railroad Avenue and paralleling the Chicago and Northwestern Railroad along Raccoon River (reference boring WDM-89-75, plates 9 and 30 of the main report) indicate marginal support for this structure. Landfill consisting of CL soils and debris (elevation 814 to 801) overlies Cahokia CL soils (elevation 801 to 798). The landfill is indicated to be of stiff consistency, whereas the Cahokia is of firm consistency. However, 5 feet of debris interbedded within the landfill may prove unsupportive to the structure, especially if inundated. Excavation of this unsuitable material may be necessary. Consistency of the CL soils is firm with indicated cohesive shear strength of 330 to 370 psf. The underlying sand was encountered at elevation 798 and penetrated 5 feet in depth.

Existing subsurface soils at the proposed gatewell (station 58+05) south of the Chicago and Northwestern Railroad adjacent to Martin Marietta sand pits and along Raccoon River (reference boring WDM-89-78, plates 8 and 29 of the main report) indicate suitable support for the structure. Except for a soft zone just above groundwater surface, the Cahokia CL, CL-CH, and CH soils are of stiff consistency (elevation 813 to 802) with indicated cohesive shear strength ranging from 480 to more than 1,000 psf. Subsurface sand was encountered at elevation 802 and was penetrated 10 feet in depth.

Existing subsurface soils at the proposed spur track single swing gate closure (station 39+34) across the Chicago and Northwestern Railroad servicing Martin Marietta and Iowa Concrete Products along the Raccoon River (reference boring WDM-89-81, plates 7 and 29 of the main report) indicate suitable support for this structure. Landfill (elevation 814 to 807) in the form of SP soils overlies Cahokia CH and CL soils (elevation 807 to 793). The landfill is loose to medium dense. The CL soils is firm with an indicated cohesive shear strength of 350 to 420 psf. The CH soils is firm to stiff and indicates 450 to 680 psf. The cahokia sits atop the bedrock shale surface (elevation 793); bedrock was penetrated 0.2 feet in depth.

Existing subsurface soils adjacent to the proposed sand bag closure (station 9+65) across the Chicago and Northwestern Railroad along Jordan Creek (reference boring WDM-89-85, plates 5 and 29 of the main report) indicates the soils

beneath natural ground surface are suitable support for the structure. Cahokia CL and CL-CH soils (elevation 815 to 805) are of stiff to very stiff consistency with indicated cohesive shear strength ranging from 540 to 660 psf and greater. Henry sand (elevation 805 to 775) underlies the Cahokia and exists in a loose to medium dense relative density. The sand sits atop the moderately hard bedrock shale surface (elevation 775); bedrock was penetrated 1.3 feet in depth. Although not explored, existing soils of the railroad embankment are presumed to be relatively porous.

SLOPE STABILITY

A review of all levee sections to be constructed of semi-compacted impervious fill indicates that the maximum levee embankment height ranges from 3 to 14 feet, except for one reach. This isolated reach from station 81+50 to 85+50 reaches a height of 20 feet. In this reach, the levee crosses an existing pond. Here, the pond will be dewatered and filled to elevation 800 with impervious fill. In addition, a 3-foot thick sand berm will be placed for underseepage concerns. Atop this, a 2-foot thick layer of random fill will be spoiled to eliminate off-site hauling. All reaches, subject to ground surface depressions and irregularities, will be filled with sand or impervious fill prior to embankment construction. The levee section at station 78+00 was selected to be the most critical with respect to riverside slope stability; station 84+00 was designated the most critical landside. The selections were based on both embankment height, steepness of slopes, and/or thickness and consistency of the impervious top stratum (Cahokia alluvium) clay foundation.

Embankment slope stability will not be a factor in areas that contain rubbish landfill. As shown on plate 23, rubbish encountered will be totally removed beneath the major portion of the proposed embankment. Rubbish is not a suitable landfill for retention. This scheme will alleviate settlement to the structure and insure stability of slopes.

The most critical section, represented by the riverward slope at station 78+00, was studied to insure the minimum factor of safety was satisfied. This section of proposed new levee will expose a height of 25 feet. The side slopes, both riverside and landside, will be shaped to 1V on 3H. The crown width will be 10 feet. The new embankment overlies 13 feet of Cahokia alluvium. The alluvium is made up of lean clay and sandy lean clay (CL soils). The sandy lean clay, some 2 feet in thickness, is sandwiched between the lean clay 3 feet beneath the surface (reference boring WDM-89-72, plates 10 and 30 of the main report). As indicated in Plate C-47, in situ shear strengths range from 400 to 480 psf for the CL soils. A value of 450 psf was

selected as the average shear strength for the soil. Examination of in situ moisture content and standard penetration tests of the impervious top stratum (Cahokia alluvium) was consistently the softest top stratum of this thickness relative to the greatest embankment height.

In situ foundation soil (impervious top stratum) shear strengths of the Cahokia alluvium were determined from undisturbed shear strength data. The data is a collection of numerous unconsolidated-undrained (quick strain) triaxial and unconfined compression tests of alluvial soils. Correlation curves for this data are shown for CL, CL-CH, and CH soils on plates C-51 through C-53, respectively. For comparison purposes, they are shown together on plate C-54. Conservative values, relative to Rock Island District as-built shear strengths, were selected for the strength of the new embankments. Unit weights and shear strengths of both embankment and foundation at the most critical section were based on evaluated assumptions. These assumptions are shown on stability plate C-61. Both standard penetration and pocket penetrometer tests support the shear strength selection.

Stability analyses were run in accordance with procedures in Engineer Manual 1110-2-1902, "Stability of Earth and Rock-Fill Dams", dated April 1970. The purpose of the analyses is to examine factors of safety for various embankment conditions to insure compliance with maximum safety standards. The circular arc analysis was determined to be the best suited method of analyzing the embankment stability. It is expected that the compacted soils will achieve and maintain some excess pore water pressure after construction for some duration of time. It is also anticipated that flooding will be of short duration and will not create a prolonged flood stage that would saturate a major portion of the riverside embankment. Due to this, the cases of sudden drawdown, partial pool, and steady seepage were not considered applicable for this study.

In the circular arc slope stability analyses it was assumed that the elevation of the potential sliding surface would be tangent to the contact of the impervious top stratum overlying the pervious substratum (foundation). In all analyses, the side earth force direction was assumed equal to the average of the embankment slopes immediately adjacent to the slice interface. A search routine was applied to find the critical failure surface having the minimum factor of safety. The number of trial circles tried for this study condition, before the minimum circle was determined, are found on plate C-63. A summary of the individual stability analyses, which includes the plot, the input data, and the output data of the critical failure surface, are shown on plates C-61 through C-64.

The most critical section is represented at station 78+00 (reference boring WDM-89-72, plates 10 and 30 of the main report); this section was selected as the design condition to analyze for the end of construction condition riverside slope. Unconsolidated-undrained (Q) shear strength values were determined for each material type. A cohesion of 1400 psf and 13 degrees frictional angle was selected for the new CH soils semi-compacted impervious fill embankment. The selected shear strength was derived from previous triaxial compression tests performed for the Rock Island District on similar soils in the immediate area. Laboratory remolded strengths ranged from 1400 psf and 11 degrees to 1740 psf and 3 degrees. Undisturbed strengths ranged from 1400 psf and 13.5 degrees to 2200 psf and 5.5 degrees. A cohesion of 450 psf for the CL soils with zero frictional angle was selected for the Cahokia alluvium impervious top stratum. Groundwater surface was established at elevation 797.5. Results of the analyses disclose the minimum factor of safety to be 1.70 with zero seismic force for the 1V on 3H riverside slope. This factor of safety (1.70) exceeds the required minimum (1.3). The analyses are shown on plate C-61. Configuration, soil constants and piezometric surface input data are shown on plate C-62. Trial search and selected minimum factors of safety are shown on plate C-63. Tabulation of slice data for the critical arc are shown on plate C-64. The minimum factor of safety was checked using program UTEXAS2 and found to be 2.11 using Spencer's method.

SETTLEMENT AND CONSOLIDATION

The entire 22,000 lineal feet of proposed new levee embankment and concrete floodwall (I-wall type) was examined for consideration of settlement study. Throughout the project alignment, isolated areas exist where the natural Cahokia alluvium has either been partially or entirely excavated and backfilled with landfill or landfill has been placed atop the Cahokia. Evaluation of the geologic profile determined that a minimum of 8 isolated areas of landfill are present along the project alignment. A variety of materials have been placed over the past 25 years in designated landfill areas. Materials present in these landfill areas range from SP, SC and CL soils to cinders, hardened waste concrete, roadbed, and rubbish. The landfill area along Lincoln Road, contained within borings WDM-89-75 thru WDM-89-77 and test pits TP-1 and TP-2, (reference plates 9 and 30 of the main report) indicates materials there to be the most undesirable. Landfill materials here are predominantly rubbish, some 5 to 9 feet in thickness, capped with 4 to 5 feet of CL soils. The rubbish extends to the pervious substratum in the center portion (boring WDM-89-76) of this area, whereas the perimeter reveals that 4 feet of Cahokia alluvium underlies 1-foot of fill (CL soils) at the base of the rubbish. Examination of the rubbish

removed from the excavated test pits revealed that garbage was intermixed in TP-1 and absent in TP-2. Boring WDM-89-75 was selected to represent this area. At this location, the proposed 6-foot high levee will impose a maximum load of about 0.4 tons per square foot (tsf) on the 16 feet of landfill and Cahokia alluvium. Of the 16 feet, boring WDM-89-75 reveals that 6 feet is rubbish landfill sandwiched between 7 feet of CL soils landfill (5 feet above and 2 feet below) and founded on 3 feet of Cahokia alluvium. Field and laboratory tests indicate that the Cahokia alluvium (CL soils) is moist in nature with a firm consistency. The CL soils landfill is also moist in nature and has a firm to stiff consistency. The rubbish indicates some degree of firmness and compactness in place. However, the contents of the rubbish indicate the potential to deteriorate with time. Additional unwanted settlement may occur but should be limited in amount. High river stages will tend to inundate this material easily, thereby causing a buoyant effect. This in turn may effect the stability of the structure. Rather than remove this rubbish, a potential shallow underseepage situation will be alleviated by extending a riverside toe cutoff trench into the underlying Cahokia. With the limited embankment height in this reach, settlement here is anticipated to be less than other reaches due to low height of levee, desiccation of the upper 5 feet, and relative compactness of the rubbish. A test section is proposed for this site to verify the amount of settlement expected. Total settlement was not determined here.

The normal environment throughout much of the project alignment indicates that landfill is absent. Boring WDM-89-72 (reference plates 10 and 30 of the main report) was selected to represent this case for settlement analysis. At this location the proposed 12-foot high levee will impose a maximum load of about 0.7 tsf on the 14-foot thick Cahokia alluvium. Field and laboratory tests indicate CL soils to be relatively moist in nature with a soft to stiff consistency. A settlement analysis conforming to Joseph E. Bowles "Foundation Analysis and Design," 3rd edition, 1982, formula 2.35, indicates total settlement to be in the order of 13 inches, as shown on plate C-65. A shrinkage allowance of 10 percent of the levee height will be provided in the specifications to allow for any consolidation of the embankment and settlement of the foundation.

No extremely soft clays were encountered throughout the project alignment. Removal of unwanted soft clays are not expected. However, extremely soft clays encountered during construction should be removed to prevent unwanted settlement.

Beyond the two cases analyzed above, there are countless subsurface conditions where variable thicknesses of landfill and Cahokia alluvium exist. It is felt that the two cases

studied represent the extreme conditions. In other cases, where landfill is of suitable materials, it is anticipated that total settlement will be somewhat less than presented.

THROUGH SEEPAGE

Through seepage will not be a factor for the new levee embankments constructed of semi-compacted impervious fill. New levees are anticipated to be composed of medium clay (CL-CH soils) and fat clay (CH soils) in mixed form. In addition, the flood duration (5 days for the Raccoon River, 1 day for Walnut Creek, and 0.5 day for Jordan Creek) is not sufficient to create a case of steady seepage.

UNDERSEEPAGE

Underseepage control measures for the project are based on a study of thickness and permeability characteristics of both the impervious top stratum and the pervious substratum and the extent of the riverward and landward top stratum. Underseepage is anticipated in the study area. Control measures in the form of seepage berms will be provided, if necessary, for ample underseepage protection against uplift and piping. The seepage berms will be free-draining with less than 5 percent passing the No. 200 sieve.

The underseepage and berm analysis used follows the criteria in "Relief Well Design", Civil Works Engineer Bulletin 55-11, dated 28 June 1955; "Investigation of Underseepage and Its Control, Lower Mississippi River Levees," Waterways Experiment Station publication Technical Memorandum 3-424, dated October 1956; and criteria contained in "Design and Construction of Levees," Engineer Manual 1110-2-1913, dated 1978. A report on "Conference of Underseepage for Agricultural Levees," NCRGT letter to OCE, Rock Island District, dated 11 October 1960 and "Tentative Criteria for Use of Underseepage Control Measures on Agricultural Levees," Office, Chief of Engineers, dated 3 June 1958 established empirical limitations on such items as maximum length of berms and permeability ratios. A further modification of this criteria resulted from the "Minutes of Geotechnical Conference" held at the Rock Island District on 29-30 April 1976. The methodology of the underseepage and berm analysis is the result of continuing documentation of the performance of existing levees during high water periods in 1965 through 1975 from Dubuque, Iowa to Hamburg, Illinois by personnel of the Geotechnical Branch. This documentation has been supplemented by continued observations during high river periods through 1990. Methodology was further established in Supplement No. 1 to Design Memorandum No. 1

for Fulton, Illinois Local Flood Protection Project, Draft, December 1976.

Design values used in determining the need for and the designing of seepage berms for levees are given in Summary of Underseepage and Berm Analysis plates C-66 through C-75. Transformed depth and permeability of the pervious substratum at locations relative to specific borings WDM-89-55, -58, -67, -70, -72, and -85 are shown on plates C-76 through C-81. A plot of effective grain size (D_{10}) versus coefficient of permeability (k_h) used in the transformation of pervious substratum is shown on plate C-82. Vertical blanket permeability ratios were selected in accordance with the April 1976 conference. The factor of safety was computed from equation 9 on page 3 of Civil Works Engineering Bulletin 55-11. If a berm was considered, the thickness was computed for a factor of safety equal to 1.50 at the levee toe in accordance with the appropriate equation shown in Figure C-1 of EM 1110-2-1913. Reaches considered for berms are reflected by hold-down factor of safety against uplift at the landside toe of levee. Levee construction on other projects indicates that the sand berm does not increase the head at the landside toe. This determination is based on piezometer readings and documented performances of sand berms since 1965. The berm length will be constructed in accordance with criteria developed in the Rock Island District for levees with sand berms at the April 1976 conference.

Results of the underseepage and berm analysis are shown on plates C-66 through C-75. The terminology reflecting the methodology established during the April 1976 conference is shown on plates C-83 through C-86. Typical sections for each levee reach are shown on plate C-39 and plate 23 of the main report. These sections show the subsurface profile developed from the pertinent borings.

A discussion of significant parameters for each specific reach of levee is not addressed. The data shown on the Summary of Underseepage and Berm Analysis (plates C-66 through C-75), the Typical Sections (plates C-39 and 23), and the Terminology of Methodology (plates C-83 through C-86) are self-explanatory. Due to the unique morphology of the project, underseepage results were found to be dependent on two specific considerations. The first consideration was the natural blanket length riverward and landward; the second consideration, the more important of the two, was whether the structure was founded on undisturbed Cahokia alluvium or on landfill impregnated into the Cahokia. Clarification of the underseepage and berm analysis results are discussed in the remarks on plates C-66 through C-75.

The amount of underseepage into the ponding areas was conservatively assumed equal to the entire flow under the

levees. The seepage beneath the levees was computed using a flood stage equal to the design levee grade and the estimated values of D, kf, Ls and Le for various reaches of the levee. The seepage flow (Q) per unit length of the levee was computed. Results of the study are shown on plate C-87. From the quantities indicated, it appears the pumping capacities planned will be adequate to control the ponding elevation for any infiltrating underseepage.

UNDERSEEPAGE CONTROL FOR PONDING AREAS

Provisions to control underseepage and to prevent the formation of boils into the ponding areas will be a primary concern at this project. Planned excavations will be discouraged inside 100 feet of the landside toe of the levee and/or berm. This scheme is considered beneficial in retaining an area sufficient in size to move equipment, laborers, and materials during periods of high river flows to accomplish a successful flood fight. This can be accomplished at all ponding areas except for Ponding Area C at Johnny's Vet's Club. Here, the distance will be reduced to 50 feet due to limited space available to incorporate the planned ponding area size.

The Fair Meadows Creek Ponding Area A is located along Fuller Road. Here, the location of the ponding area exceeds (1,500 feet) the minimum (100 feet) required distance from any source of underseepage infiltration. Excavation of the ponding area will entertain the removal of a portion of the Cahokia alluvium impervious top stratum. Some 4 to 5 feet of CH soils will be removed and used for levee construction. Bottom grade of the ponding area is anticipated to be elevation 812.8 NGVD (39.0 city datum). Some 7 to 9 feet of Cahokia CH, CL-CH, and SC soils will remain. The pervious aquifer is some 20 to 30 feet thick in this area. Both the remaining top stratum thickness and the excessive distance to the source of potential seepage entry is sufficient to prevent infiltration of underseepage. No pumping station is planned for this location.

Ponding Area B is located along the C&N RR near the intersection of Jordan Creek. Here the ponding area naturally contours the existing ground surface. Former explorations indicated that an excess of 15 feet of Cahokia alluvium exists in the presence of CL, CL-CH, and CH soils. This material will remain intact. The pervious aquifer is some 30 feet in thickness here. No excavations are planned at this location. Distance to the potential effective source of seepage entry exceeds 500 feet. No pumping station is planned for this location.

The Johnny's Vet's Club Ponding Area C is located along Lincoln Road. Here, the location of the ponding area is in

excess of 1,500 feet from the Raccoon River. However, a much lesser distance exists to the open Martin-Marietta sand pits where the entrance to infiltration of underseepage exists. At this location, the existing thickness of Cahokia alluvium CL and CL-CH soils is not consistent. The center portion of the area contains 11 to 18 feet, whereas the perimeter Cahokia has been removed and replaced with landfill. An unknown portion of this landfill is hardened waste concrete. Some 10 to 15 feet of material will be removed. The landfill will be disposed of in depression fills. The Cahokia CL and CL-CH soils will be used for levee construction. The bottom grade of the ponding area is anticipated to be 799.8 NGVD (26.0 city datum). Some 3 to 6 feet of Cahokia CL and CL-CH soils in addition to the hardened concrete will remain. The pervious aquifer is thickest (some 35 feet) at this location. The remaining top stratum thickness and distance to potential source of seepage entry is marginal to prevent underseepage infiltration. A pumping station is planned for this site. A minimum of two relief wells will be installed to the bedrock surface for control of uplift pressures at the station. The proposed installation is based on documented performance at 23 pumping station sites of similar subsurface conditions throughout the Rock Island District. Instrumentation recordings during high river stages have verified that pumping stations protected by at least two fully penetrating relief wells have experienced reduced uplift pressures and uninterrupted operation. A relief well design analysis is not planned for this site.

The Walnut Creek Ponding Area D is located along Valley Drive and 59th Street. The location of the ponding area exceeds 300 feet from any source of underseepage infiltration. Excavation of the ponding area will remove a portion of the Cahokia alluvium. Some 4 to 5 feet of CL and CH soils will be removed and used for levee construction. The bottom grade of the ponding area is planned for elevation 801.8 (28.0 city datum). Some 7 to 9 feet of CL, CL-CH, and CH soils will remain. The pervious aquifer is some 15 feet in thickness. Both the remaining top stratum thickness and the sufficient distance to the source of potential seepage entry is sufficient to prevent underseepage infiltration. No pumping station is planned for this location.

Low area ponding in the streets and parking lots at 63rd Street and Grand Avenue experiences ponded water during heavy rainfalls. Here no excavation is necessary. A pumping station will be placed at the Valhigh storm sewer to collect intercepted flows during blocked gravity conditions. Some 12 feet of Cahokia and landfill (CL soils) exist and are underlain by 25 feet of pervious aquifer. No underseepage infiltration is expected here.

SLOPE PROTECTION

Heavy timber growth is evident along the proposed alignment. The alignment parallels Walnut Creek, Raccoon River, and Jordan Creek. Although severe wave wash is not anticipated at this project, the existing trees should afford ample protection to control erosive action against the embankment. Past history indicates overbank flash flooding along both Walnut Creek and Jordan Creek is the major concern here. Duration of overbank flash flooding along Walnut Creek is 12 hours. Duration along Jordan Creek is 6 hours. Raccoon River overbank flood duration in the summer months is 3 days with 1 day at peak. During the spring snowmelt, the duration increases to 7 days of flooding. The portion of the project that contains impervious fill levee embankment will be seeded with grass to provide slope protection. Along Walnut Creek from the Muffler Clinic (station 175+00) to the 63rd Street roadway crossing at Midland Brick (station 192+71), floods will be contained by I-walls. Past history indicates velocities have eroded a 400-foot strip of the Walnut Creek streambank in this reach. The design features of the new I-wall should alleviate this problem. If necessary, riprap and bedding stone will be provided to prevent erosive and undermining action by flash flood flow velocities between stations 170+00 and 174+00.

AVAILABILITY OF CONSTRUCTION MATERIALS

Impervious borrow material for this project will come primarily from local sites. A search was conducted during the exploration program to locate local sources of impervious borrow for construction of the semi-compacted levee sections. Two proposed ponding areas were explored for this purpose; one was immediately adjacent to the alignment, and the other was 1/4 mile away. Fifty pounds of material were collected in bags representing each soil type. Particular attention was directed to the upper 5 feet of impervious top stratum (clay) in each borrow site. The samples were transported to the district laboratory for examination and testing. Standard compaction curves of each soil type were run to determine conditioning limitations and to provide construction moisture-density guidelines.

The Walnut Creek ponding area D, located at Valley Drive and 59th Street (plate 27 of the main report) immediately adjacent to the alignment, encompasses an area of 8 acres. It is planned to final dress this site to elevation 801.8 NGVD (28.0 city datum), incorporating an excavation of some 5 feet in depth. Five drill borings (plate 34 of the main report) were placed within the proposed borrow site. Each boring was extended 15 feet in depth. In all but one case, the borings extended through the impervious top stratum

(clay). Groundwater was found to be constant; nearly 12 feet below the ground surface at elevation 796 NGVD. The impervious top stratum was composed of CL, CL-CH, and CH soils. Atterberg limits were initially run from jar samples; liquid and plastic limits were recorded as 57/22, 51/16, and 51/18. Jar samples from all 5 borings were laid out in the laboratory in accordance with elevation, and then they were inspected for soil-type horizons. Two horizons were established. The upper horizon composed the top 3 feet beneath the ground surface; five feet were in one boring. The material gave the appearance of top soil (gray in color) and made up of CL-CH and CH soils. These medium and fat clay soil types were processed in the laboratory, and then they were blended to represent mixed borrow soils. Classification tests of the blended soils indicated the Atterberg limits to be 53/22. The specific gravity, tested in accordance with ASTM-D 854, was determined to be 2.60. The lower horizon was composed of similar materials from the 3- to 15-foot depth with the exception of one boring. The exception indicated the presence of sand at these depths and is thought to be an isolated case. This material is brown in color and composed of CL, CL-CH, and CH soils. These lean, sandy lean, medium, and fat clay soils were processed and blended to represent mixed borrow soils for this horizon. Classification tests of the blended soils indicated the Atterberg limits to be 53/18. Standard proctor tests (plates C-40 and C-41) were run. Optimum moisture contents of both horizon materials that are necessary to achieve maximum density were found to be 23.3% for the upper CL-CH and 22.2% for the lower CL-CH. These optimums were found to be higher than the plastic limit (1% upper and 4% lower). These results verified the borrow material to be within allowable deviation from optimum moisture content (plate C-45). Borrow proposed for this project will entail the entire upper (3 feet) and a portion (2 feet) of the lower horizon soil; no conditioning will be required. The contractor will be encouraged to thoroughly blend the soils prior to placement in order to achieve maximum density. A shrinkage factor, not to exceed 25 percent, should be anticipated for these soils.

The Fair Meadows Creek ponding area A is located along Fuller Road (plate 24) one-quarter mile from the alignment and encompasses 20 to 27 acres. It is planned to final dress this site between elevation 816.8 to 812.8 NGVD (43.0 to 39.0 city datum), incorporating an excavation of some 5 feet in depth. Explorations were taken in April 1965. Four hand auger borings (plate 34 of the main report) were placed within the proposed borrow site. Three borings were extended into the impervious top stratum (clay) 10 to 12 feet in depth; the fourth boring extended 14 feet in depth and penetrated through the impervious top stratum (clay) into the underlying pervious aquifer. Groundwater was encountered at elevation 808 NGVD. The impervious top

stratum was composed of SC, CL, CL-CH, and CH soils. No Atterberg limits were run. No bag samples for laboratory compaction tests were obtained at this time. Supplemental to these, additional explorations were taken in October 1989. Three drill borings were placed within the proposed borrow site. Each boring was extended through the impervious top stratum (clay) to some 15 feet in depth. Groundwater was encountered in only one boring, which was located some 14 feet below the ground surface at elevation 803. The impervious top stratum was composed of SC, CL-CH, and CH soils. Atterberg limits, initially run from jar samples, were recorded as 52/18 and 64/20. Jar samples from the 3 borings drilled in 1989 were laid out in the laboratory in accordance with elevation and then inspected for soil type horizons. Three horizons were established. The upper horizon composed the top 7 feet beneath the ground surface. The horizon was gray in color and composed of CH soils. Samples obtained from the upper 5 feet of this horizon were fat clay soil types that were processed and then blended to represent mixed borrow soils. Classification tests of the blended soils indicated the Atterberg limits to be 57/19. The specific gravity, tested in accordance with ASTM-D 854, was determined to be 2.63. The middle horizon was composed of sandier and lesser plasticity soils from the 7- to 9-foot depth. One of the 3 borings indicated that this material extended to over 13 feet. This horizon is brown in color and made up of CL and CL-CH soils. These lean and sandy medium clay soils were processed in the laboratory and then blended to represent mixed borrow soils. Classification tests of the blended soils indicated the Atterberg limits to be 46/16. The lower horizon was composed of extremely sandy soils from the 9- to 12-foot depth in 2 of the 3 borings. The odd boring did not indicate a lower horizon. The horizon is brown in color and made up of SC soils. Samples obtained from this horizon were clayey sand soil types. These were processed in the laboratory and blended in order to represent mixed borrow soils. Classification tests of the blended soils indicated the Atterberg limits to be 32/12. Standard proctor tests (plates C-42 through C-44) were run. Optimum moisture contents of each horizon material that are necessary to achieve maximum density were found to be 25.0% for the upper CH, 20.1% for the middle CL-CH, and 12.4% for the lower SC. These optimums were found to be higher than the plastic limit (6% upper, 4% middle, and 0.5% lower). These results established the upper horizon borrow to be within, the middle horizon to be slightly wet of, and the lower horizon to be considerably wet of allowable deviation from optimum moisture content (plate C-45). Borrow proposed for this project will entail only the upper (5 feet) horizon soil; no conditioning will be required. The contractor will be encouraged to thoroughly blend the soils prior to placement in order to achieve maximum density. A shrinkage factor,

not to exceed 25 percent, should be anticipated for these soils.

In addition to the ponding areas, existing embankment soils are available. These embankments will be cleared of brush and trees; the materials will be pushed aside and reclaimed for use in new embankments. These existing embankment soils were investigated during foundation explorations in 1965. The impervious soils indicated a range in moisture contents from 12 to 33 percent for CL soils, 25 percent for CL-CH soils, and 23 to 39 percent for CH soils. In comparison to ponding area soils, it is anticipated these soils will have similar optimum moisture contents and will require some conditioning (drying) prior to placement and compaction.

As a secondary source of impervious borrow, the remote 30-acre site located at South 50th Street and Grand Avenue in West Des Moines, Iowa is available. Previous explorations of this hilltop site indicate loess origin SC, CL, and CL-CH soils. Limited amounts of SP soils were also noted at this site. Should this site be deemed necessary to supplement local sources of borrow, additional explorations will be taken to provide construction moisture-density guidelines to ensure acceptable compaction. Guidelines will be established by moisture contents of the soils in situ and by compaction curves of various soil types.

Pervious sand borrow necessary for depression filling and/or pervious free-draining underseepage berms can be obtained from local sources. These sources include the Raccoon River and the Martin-Marietta sand pits. Sand from these sources should be relatively well graded with less than 5 percent by weight passing the No. 200 sieve. The preferred sand should be coarse to fine with a D_{10} size ranging from 0.12 to 0.55 millimeters and having a desired average of 0.25 millimeters. The available sand found locally is generally gravelly in nature. The D_{10} size ranges from 0.10 to 0.40 millimeters for SP-SC and SW-SC soils (material containing between 5 to 12 percent by weight passing the No. 200 sieve) and from 0.18 to 0.38 millimeters for SP soils (material containing less than 5 percent by weight passing the No. 200 sieve). This material would be acceptable to perform its intended function.

Protection (riprap and bedding) and roadway stone are available in the immediate area, as are concrete coarse and fine aggregates. However, stone of acceptable quality may entail hauling a distance of 50 miles to the project site. Other forms of velocity protection in comparison to the desired quality that riprap and bedding stone provide may be more cost effective to use.

MATERIAL UTILIZATION

It was preconceived that excavation of unsuitable materials, specifically in the form of landfill, was expected at the project site. Previous explorations were conducted by other firms prior to 1989. These explorations within the project alignment corridor indicated that the extent of landfill was as much as 8 feet. However, it was not determined from these explorations if these extents were isolated areas that would have less than significant impact on the project site. Additionally, there was a concern that the landfill placement may have been uncontrolled. At the request of the Rock Island District Environmental Analysis Branch, the Iowa Department of Natural Resources (DNR) was contacted in May 1988 concerning this matter. The DNR confirmed that the landfill dump site at Lincoln Road and Railroad Avenue, within the project alignment corridor, was being used for a normal domestic waste and fly ash site and was not on the list for uncontrolled sites. Recent explorations throughout the project alignment corridor confirmed that landfill was present (plate C-3). Most landfill materials encountered outside the confines of the aforementioned site were variable. CL soils dominated most landfill sites. Both SC and SP soils were found at one isolated site that contained a pocket of rubbish and cinders. Other isolated sites indicated either roadbed or hardened waste concrete landfill. The extent of these landfills reaches 20 feet in thickness. The landfill at the aforementioned site was found to extend to 13 feet. The site contained some 5 to 9 feet of rubbish capped with 4 to 5 feet of CL soils. Site excavations here revealed the rubbish was intermixed with garbage in test pit TP-1. Methane gas is recognized as a hazard in landfill areas. During the December 1989 excavations in the city landfill at station 61+00 to 54+00, no detection of methane gas was recorded. This precaution will be presented in the specifications to coordinate with the inspection trench excavations. It appears feasible that all landfill (CL, SC, and SP soils) can be reclaimed and reused in construction areas where directed by the construction inspector. Some of this material (CL and SC soils) may be suitable for embankment construction; the remainder (SP soils) can be used for depression fill or berm construction. CL, CL-CH, and CH soils obtained from existing levees and from proposed inspection trench excavations can be reused for inspection trench and embankment construction. Proper conditioning (either wetting or drying back) will be necessary prior to placement and compaction. Material obtained from ponding areas A and D is acceptable as is (no conditioning required). In sites where rubbish and garbage are encountered, removal will be necessary.

FLOOD HISTORY

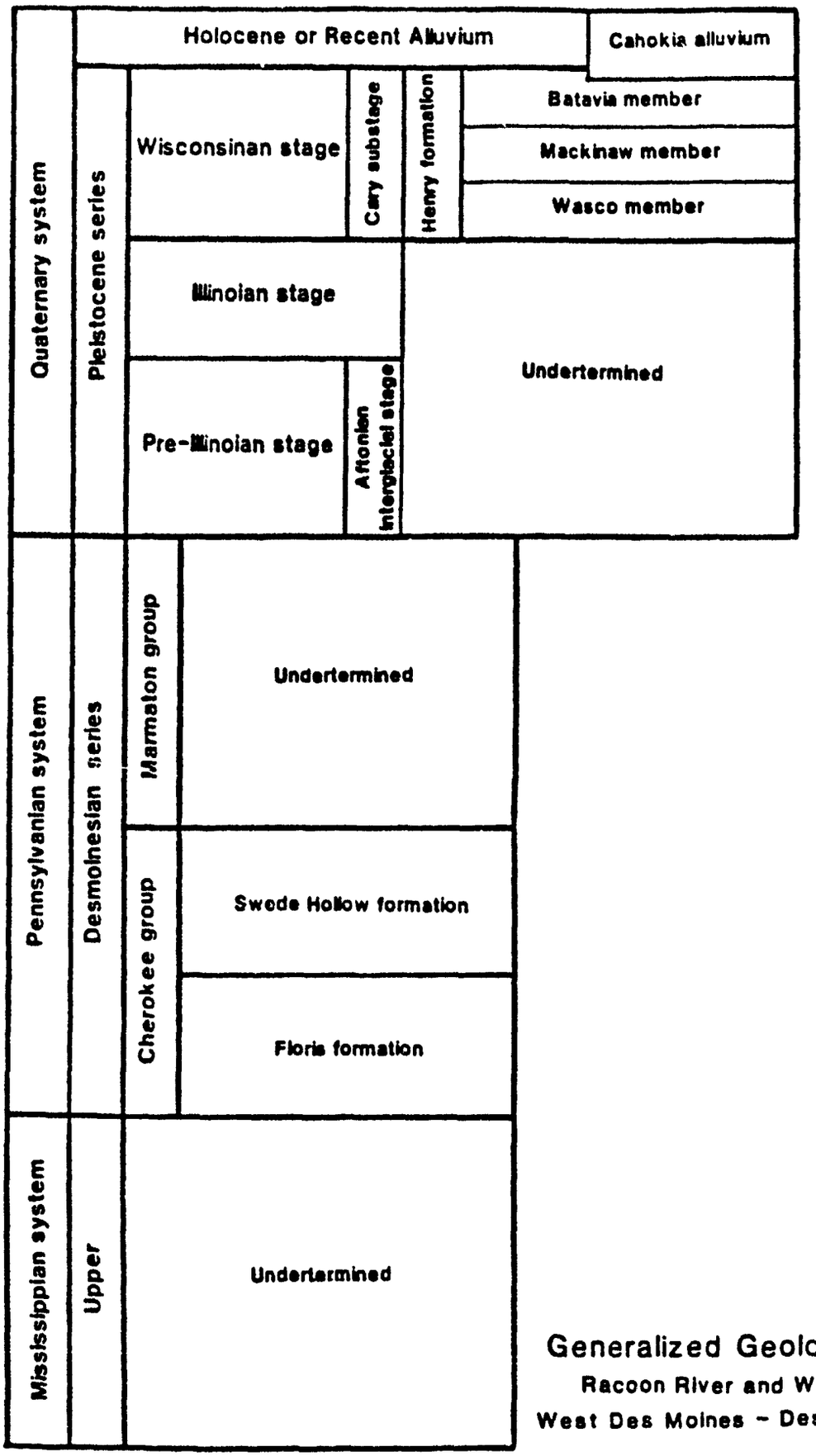
Records indicate that high water, significant in magnitude to cause flooding, has occurred on both the Raccoon River and Walnut Creek. Major flooding on the Raccoon River occurred in 1947, 1973, 1986, and 1990. The flood of record was a 40-year event, occurring in June 1947 with peak flows of 35,000 to 40,000 cubic feet per second (cfs). Lesser events occurring in July 1973 recorded a 25-year event, and July 1986 and June 1990 were slightly less. Major flooding on Walnut Creek occurred in 1973, 1974, 1975, 1986, and 1990. The flood of record was a 40-year event occurring in May 1986 with peak flows at 12,500 cfs. The lesser July 1973, June 1974, and August 1975 events yielded peak flows of 9,000 cfs, 8,160 cfs, and 5,800 cfs, respectively.

INSTRUMENTATION

Piezometers are nonexistent at the project site. Prior to, during, or upon completion of levee construction, consideration will be given to placing up to three ranges of piezometers. The purpose of the ranges will be to monitor groundwater fluctuations and underseepage pressures. These installations would allow the opportunity to collect and evaluate high water data for use in comparing with underseepage control measures determined in the study. Installations would be provided with impervious seals to prevent influence from infiltration of surface water. At Walnut Creek, a range would be placed in the vicinity of station 212+00. Here, the levee is 10 feet in height. The Cahokia alluvium impervious top stratum is 14 feet in thickness. The natural blanket length riverward to the underseepage entrance is 100 feet. The natural blanket length landward to the underseepage exit is infinite. At the Raccoon River, a range would be placed in the vicinity of station 78+00. Here, the levee is 12 feet in height. The top stratum is composed of Cahokia alluvium, 14 feet in thickness. The natural blanket length riverward to the underseepage entrance is 400 feet. The natural blanket length landward to the underseepage exit is infinite. At Jordan Creek, a range would be placed in the vicinity of station 12+00. Here, the levee is 7 feet in height. The Cahokia alluvium impervious top stratum is 10 feet in thickness. The natural blanket length riverward to the underseepage entrance is 400 feet. The natural blanket length landward to the underseepage exit is infinite.

Settlement plates will be considered for placement in areas indicating the presence of unsuitable landfill, particularly rubbish. These plates will be installed prior to construction. The plates will serve to monitor settlement of the foundation relative to rate of embankment loading. Conditions conducive to this are in the vicinity of borings WDM-89-75, WDM-89-76, and WDM-89-77 and test pits TP-89-1 and TP-89-2 (reference plate 9 of the main report).

Subsurface stratigraphy is best represented by boring WDM-89-75 (reference plate 30 of the main report). Test pit TP-89-1 (reference plate 30 of the main report) best depicts the unsuitable subsurface landfill. Plates will be installed in the foundation at three significant levels: at the top of the CL landfill (elevation 814), at the top of the rubbish (elevation 809), and at the bottom of the rubbish (elevation 803). Installing a plate in the 6-foot high embankment is not planned.

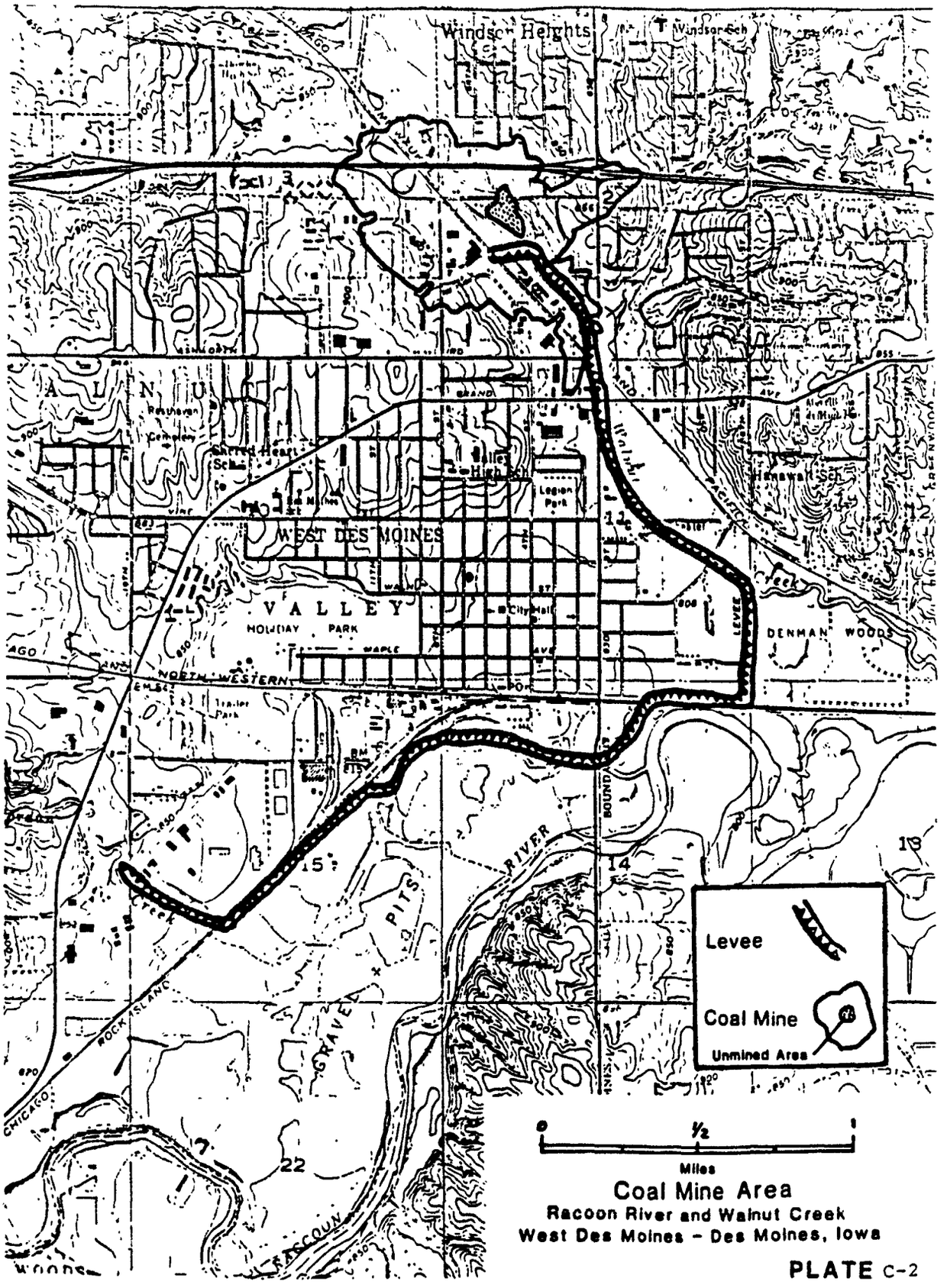


Generalized Geologic Column

Racoon River and Walnut Creek

West Des Moines - Des Moines, Iowa

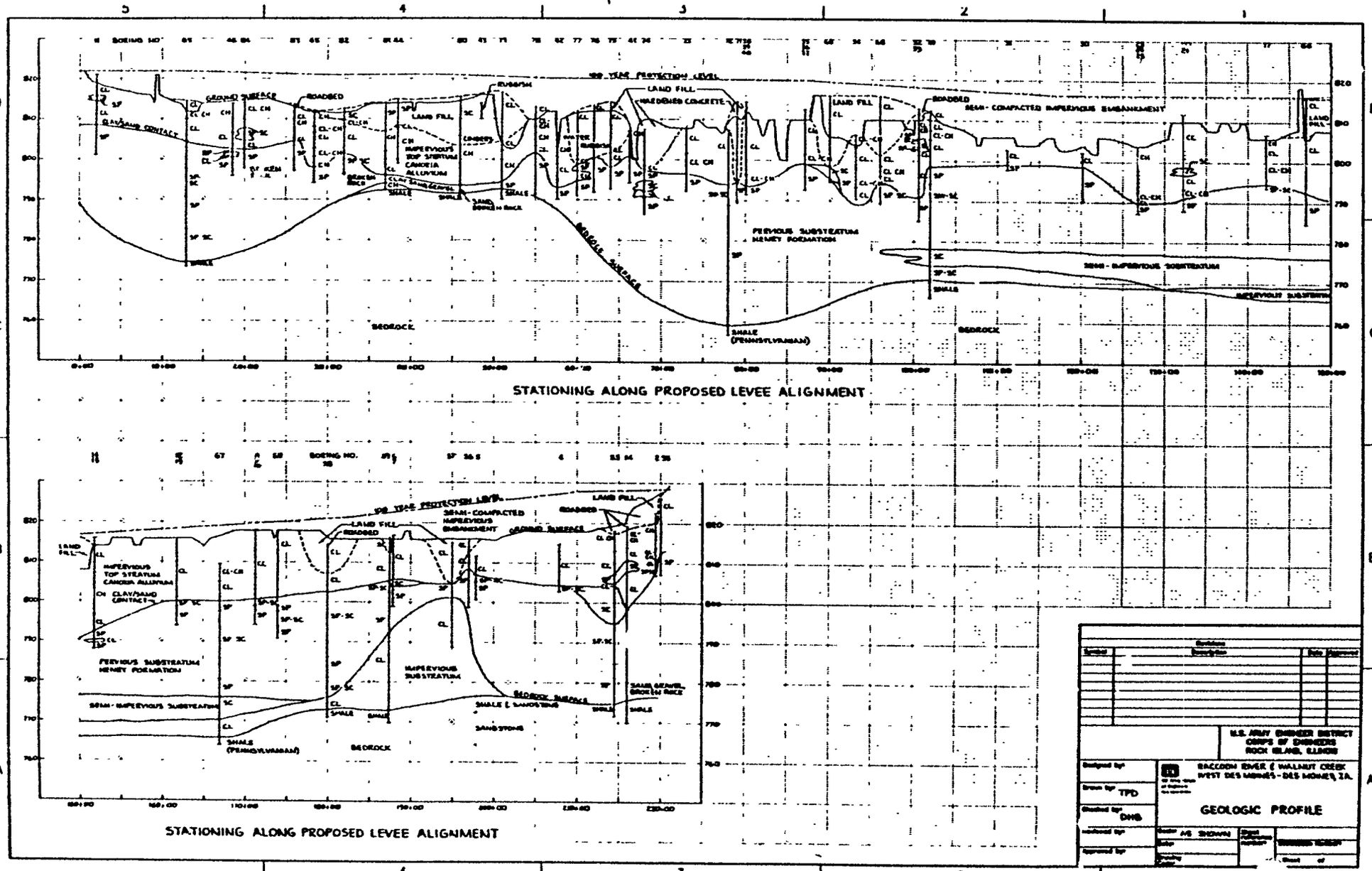
PLATE C-1



Coal Mine Area

Racoon River and Walnut Creek
West Des Moines – Des Moines, Iowa

PLATE C-2



U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

RACCOON RIVER & WALNUT CREEK
WEST DES MOINES - DES MOINES, IA.

GEOLOGIC PROFILE

Designed by:
Drawn by: TPD
Checked by: DHB
Approved by:

PLATE C-3

EXPLORATION PROGRAM
FOR
GENERAL DESIGN MEMORANDUM
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA

EXPLORATORY DRILLING
PHASE 2

Drilling on-site shall require the use of one (1) all-terrain vehicle (Drill Rig A) or one (1) truck (Drill Rig B), mounted rotary drill, accessory equipment, and operating personnel to drill 55 holes along the levee alignment ranging from 15 to 60 feet in depth. Five (5) inch hollow stem augers will be used to obtain standard penetration split spoon samples at every 2.5-foot interval depth through the impervious top stratum (clay), 5-foot interval depth through the pervious substratum (sand), and 2.5-foot interval depth into the soft bedrock (shale and/or sandstone). Firm to hard bedrock shall be cored (NX or NQ) in 5-foot runs. Pocket penetrometer tests shall be taken at every 0.5 feet of each split spoon sample of the impervious top stratum (clay). Blow counts shall be recorded at each 6-inch interval. Jar samples shall be taken of each standard split spoon and auger sample. Samples shall be surface cleaned prior to placement into wide mouth glass jars for transportation to the district laboratory for classification and testing. Four (4) inch or six (6) inch Iwan augers shall be used to sample every 2-foot interval depth through the impervious top stratum (clay) and to obtain bag samples in both the 10 acre and Fair Meadows

Creek borrow ponding areas. Bag samples of not less than 30 pounds shall be collected representing each soil type in the upper 5-feet of the impervious top stratum (clay) of each borrow area. All borings shall be assigned WDM-89-__. Begin numbering of borings with 53. Reference logs of borings (3 sheets) and locations (1 sheet) of existing borings WDM-65-1 thru -52 (shown in dark blue) for anticipated foundation soils. Proposed borings designated "Red Borings" (40 total) and proposed borings designated "Blue Borings" (15 total) shall commence in September 1989.

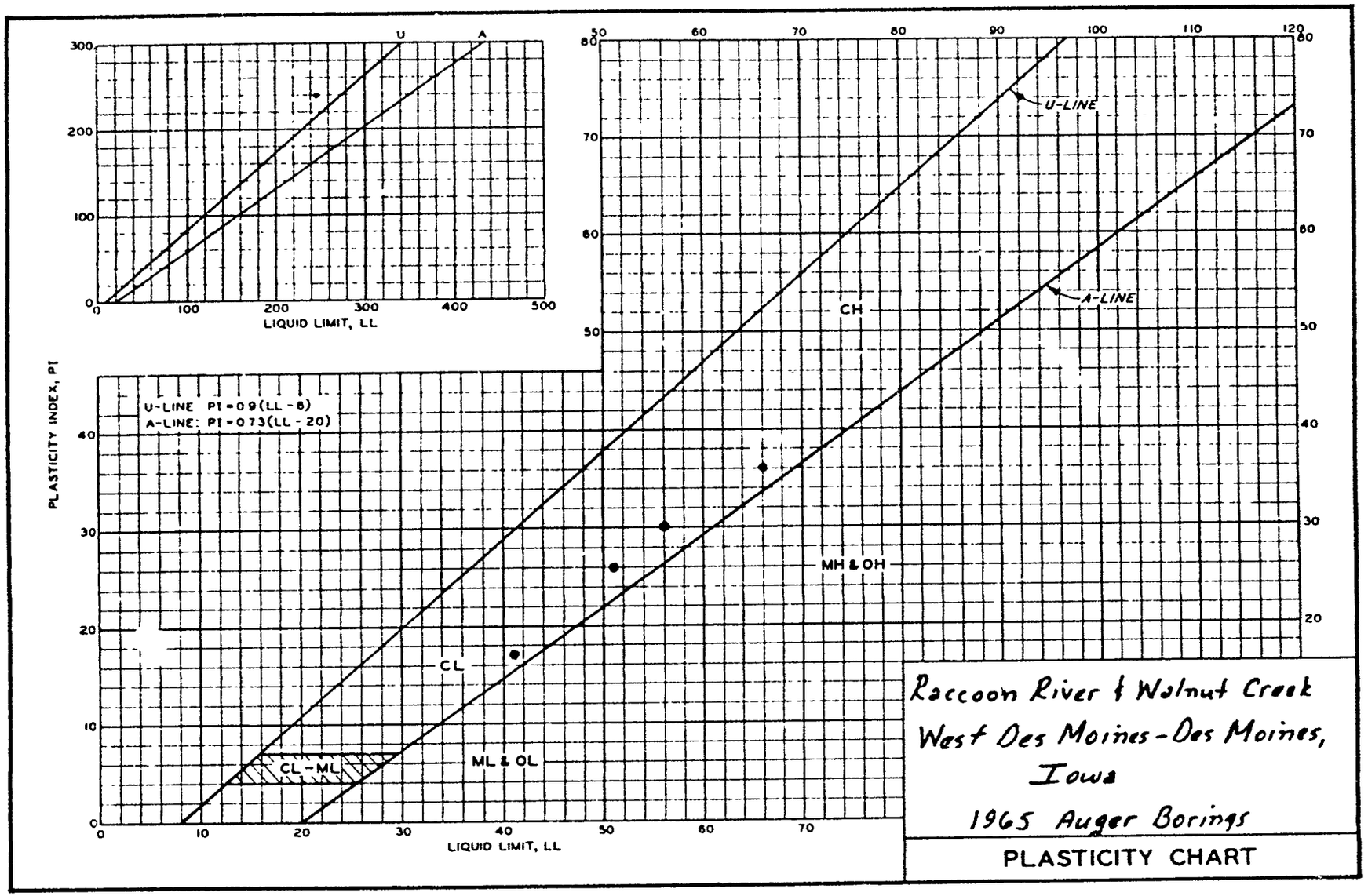


PLATE C-5

ENG FORM 4334 JUN 70 (EM 1110-2-1906) TRANSLUCENT

RED BORINGS

Drill Boring Number Desgn. (Assgn)	Station Location of Boring	Termination of Boring	Estimated Depth of Boring	Purpose
1 (a)	217	5′ into bedrock	55′	Structure - Walnut Creek, railroad closure with sheet piling
2 (54)	216	Core 5′ into bedrock	55′	Structure - Walnut Creek, railroad closure with sheet piling
3 (55)	215	Split Spoon 5′ into bedrock	55′	Structure - Walnut Creek, lumberyard closure
4 (c)	190	5′ into bedrock	45′	Structure - Walnut Creek, Ashworth Road closure in railroad corridor
(c)	189	5′ into bedrock	50′	Structure - Walnut Creek, Ashworth Road closure in railroad corridor
5A (59k)	187	Core 5′ into bedrock	50′	Structure - Railroad closure single swing gate
6 (58)	186	Core 5′ into bedrock	50′	Structure - Walnut Creek, beginning of concrete I-Wall with sheet piling, gatewell and pump station
7 (c)	183	5′ into bedrock	50′	Structure - Walnut Creek, swing gate closure for concrete I-Wall w/ sheet piling
8 (c)	182	5′ into bedrock	50′	Structure - Walnut Creek, swing gate closure for concrete I-Wall w/ sheet piling
9 (c)	180	thru impervious top stratum (clay), into pervious substratum (sand)	20′	Structure - Walnut Creek, concrete I-Wall with sheet piling

RED BORINGS - CONT.

Drill Boring Number Desgn. (Assgn)	Station Location of Boring	Termination of Boring	Estimated Depth of Boring	Purpose
10 (c)	178	thru impervious top stratum (clay), into pervious substratum (sand)	20′	Structure - Walnut Creek, end of concrete I-Wall w/ sheet piling
11 (c)	174	5′ into bedrock	50′	Structure - Walnut Creek, levee closure gate
12 (60)	174	5′ into pervious substratum (sand)	45′	Structure - Walnut Creek, levee closure gate
13 (62)	145	thru impervious top stratum (clay)	15′	Borrow - Walnut Creek, 10 acre Ponding Area (5′ deep)
14 (61)	146	thru impervious top stratum (clay)	15′	Borrow - Walnut Creek, 10 acre Ponding Area (5′ deep)
15 (63)	144	thru impervious top stratum (clay)	15′	Borrow - Walnut Creek, 10 acre Ponding Area (5′ deep)
16 (64)	144	thru impervious top stratum (clay)	15′	Borrow - Walnut Creek, 10 acre Ponding Area (5′ deep)
17 (65)	141	thru impervious top stratum (clay)	15′	Borrow - Walnut Creek, 10 acre Ponding Area (5′ deep)
18 (70)	101	Core 5′ into bedrock	50′	Structure - Raccoon River, railroad closure, double swing gate
19 (a)	101	5′ into bedrock	50′	Structure - Raccoon River, railroad closure, double swing gate
20 (68)	96	5′ into pervious substratum (sand)	20′	Levee - Raccoon River, explore for extent of trash landfill
21 (69)	89	5′ into pervious substratum (sand)	20′	Structure - Raccoon River, levee sand bag closure, underseepage concern

RED BORINGS - CONT.

Drill Boring Number Desgn. (Assgn)	Station Location of Boring	Termination of Boring	Estimated Depth of Boring	Purpose
22 (72)	78	Core 5' into bedrock	45'	Structure - Raccoon River, Pump Station
22A (71k)	76	thru concrete waste, 5' into pervious substratum (sand)	20'	Ponding Area
23 (74)	68	5' into pervious substratum (sand)	20'	Levee - Raccoon River, explore for extent of dump landfill
24 (75)	64	5' into pervious substratum (sand)	20'	Levee - Raccoon River, explore for extent of dump landfill
25 (76)	62	5' into pervious substratum (sand)	20'	Levee riverside entrance - Raccoon River, explore for extent of garbage dump landfill
26 (77)	60	5' into pervious substratum (sand)	20'	Levee - Raccoon River, explore for extent of garbage dump landfill
27 (a)	58	5' into pervious substratum (sand)	20'	Levee riverside entrance - Raccoon River, explore for extent of garbage dump landfill
28 (78)	55	5' into pervious substratum (sand)	20'	Levee - Raccoon River, explore extent of landfill area
29 (79)	51	5' into pervious substratum (sand)	20'	Levee - Raccoon River, explore extent of landfill area
30 (80)	46	5' into pervious substratum (sand)	20'	Levee - Raccoon River, explore extent of landfill area
31 (81)	37	5' into pervious substratum (sand)	20'	Levee - Raccoon River
32 (82)	32	5' into pervious substratum (sand)	20'	Levee - Raccoon River

RED BORINGS - CONT.

Drill Boring Number Desgn. (Assgn)	Station Location of Boring	Termination of Boring	Estimated Depth of Boring	Purpose
33 (83)	26	5′ into pervious substratum (sand)	20′	Levee - Raccoon River
34 (84)	20	5′ into pervious substratum (sand)	20′	Levee - Raccoon River
35 (85)	13	Split Spoon 5′ into bedrock	55′	Levee - Raccoon River, underseepage concern
36 (d)	8	5′ into pervious substratum (sand)	20′	Levee - Jordan Creek
37 (86)	SW corner	thru impervious top stratum (clay)	15′	Borrow - Fair Meadows Creek Ponding Area (5′ deep)
38 (87)	NE corner	thru impervious top stratum (clay)	15′	Borrow - Fair Meadows Creek Ponding Area (5′ deep)
39 (88)	NW corner	thru impervious top stratum (clay)	15′	Borrow - Fair Meadows Creek Ponding Area (5′ deep)
40 (e)	SE corner	thru impervious top stratum (clay)	15′	Borrow - Fair Meadows Creek Ponding Area (5′ deep)

BLUE BORINGS

Drill Boring Number Desgn. (Assgn)	Station Location of Boring	Termination of Boring	Estimated Depth of Boring	Purpose
1 (53)	220	5′ into pervious substratum (sand)	20′	Levee - Walnut Creek
2 (f)	212	5′ into pervious substratum (sand)	15′	Levee - Walnut Creek
3 (f)	203	5′ into pervious substratum (sand)	15′	Levee - Walnut Creek
4A (56k)	197	thru fill, 5′ into sand	15′	Levee - Walnut Creek
4B (57k)	195	thru fill, 5′ into sand	15′	Levee - Walnut Creek
4 (a)	194	5′ into pervious substratum (sand)	15′	Levee - Walnut Creek
5 (67)	167	Split Spoon 5′ into bedrock	25′	Levee or I-Wall - Walnut Creek
6 (g)	157	thru embankment, 5′ into pervious substratum (sand)	25′	Levee - Walnut Creek
7 (66)	147	thru embankment, 5′ into pervious substratum (sand)	30′	Levee - Walnut Creek
8 (g)	137	thru embankment, 5′ into pervious substratum (sand)	30′	Levee - Walnut Creek
9 (h)	127	thru embankment, 5′ into pervious substratum (sand)	25′	Levee - Raccoon River
10 (i)	122	5′ into pervious substratum (sand)	20′	Levee - Raccoon River
11 (d)	117	5′ into pervious substratum (sand)	20′	Levee - Raccoon River
12 (d)	112	5′ into pervious substratum (sand)	20′	Levee - Raccoon River

BLUE BORINGS - CONT.

Drill Boring Number Desgn. (Assgn)	Station Location of Boring	Termination of Boring	Estimated Depth of Boring	Purpose
13 (d)	107	5′ into pervious substratum (sand)	20′	Levee - Raccoon River
14 (j)	84	5′ into pervious substratum (sand)	20′	Levee - Raccoon River
15 (73)	73	5′ into pervious substratum (sand)	20′	Levee - Raccoon River

LEGEND

(a) Eliminate drill hole

(b) Hole staked for drilling

(c) Hole not staked for drilling; hold until alignment firm

(d) Hole not staked for drilling; access difficult, hand auger, hold until later

(e) Hole not staked for drilling; no access, hand auger, hold until later

(f) Hole not staked for drilling; access difficult, hand auger, hold until alignment firm

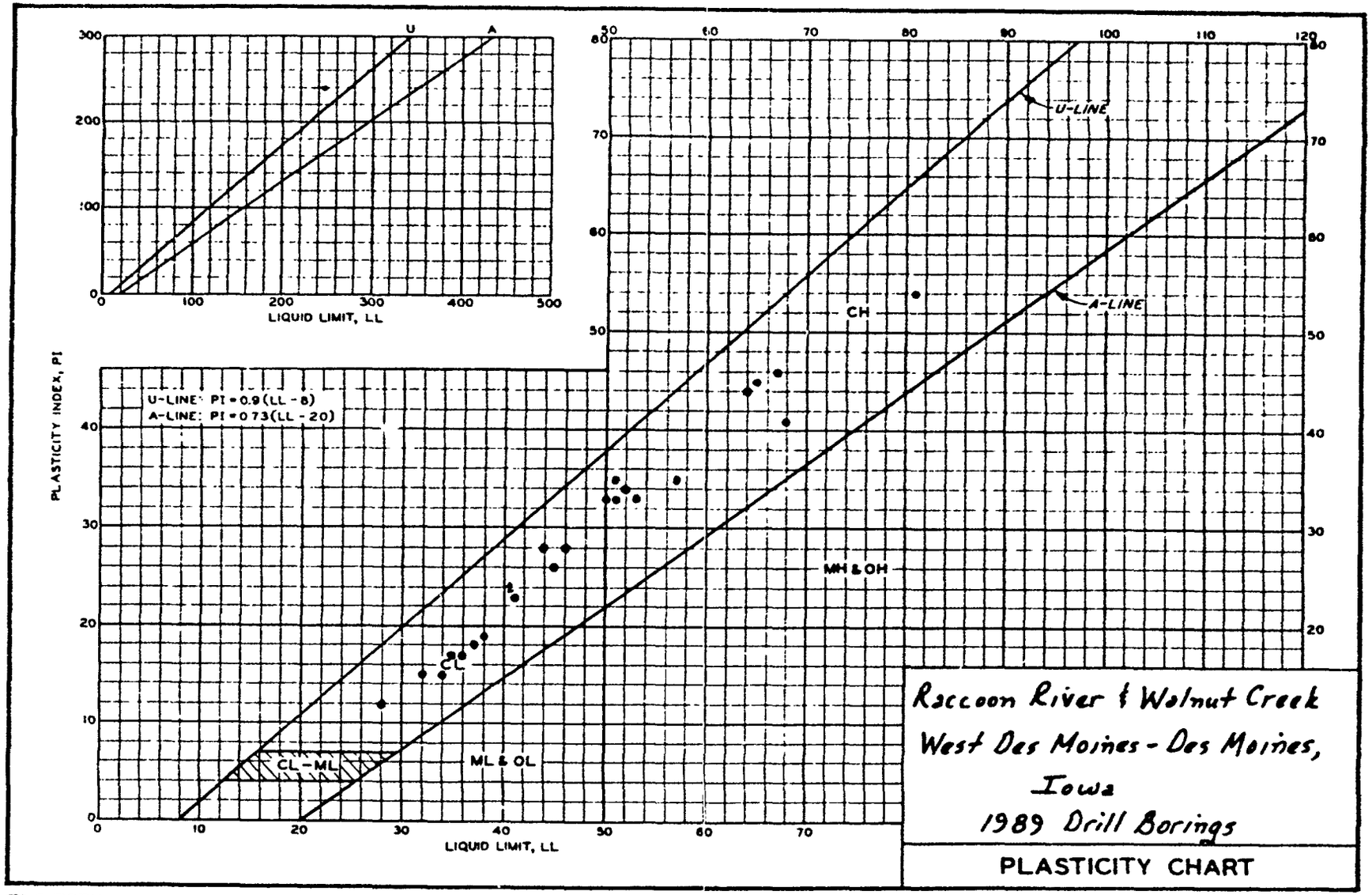
(g) Hole not staked for drilling; no access with drill rig, hand auger, hold until vegetation gone

(h) Hole not staked for drilling; no access with drill rig, private land, hold until later

(i) Hole not staked for drilling; access difficult, private land, hold until later

(j) Hole not staked for drilling; poor access, remote, hand auger, hold until later

(k) Supplement hole staked for drilling

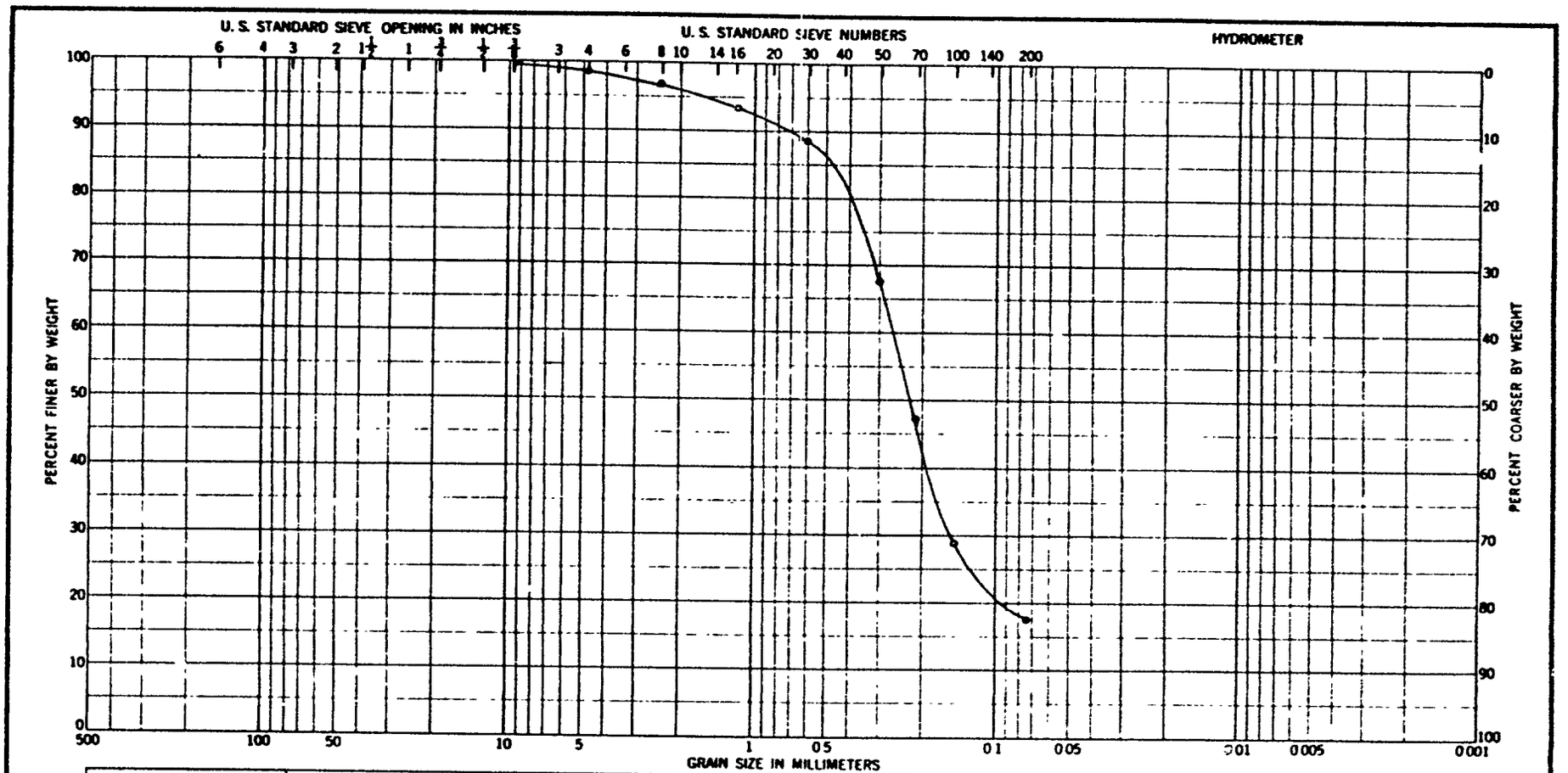


Raccoon River & Walnut Creek
West Des Moines - Des Moines, Iowa
1989 Drill Borings

PLASTICITY CHART

PLATE C-6

ENG FORM 4334 JUN 70 (EM 1110-2-1906) TRANSLUCENT



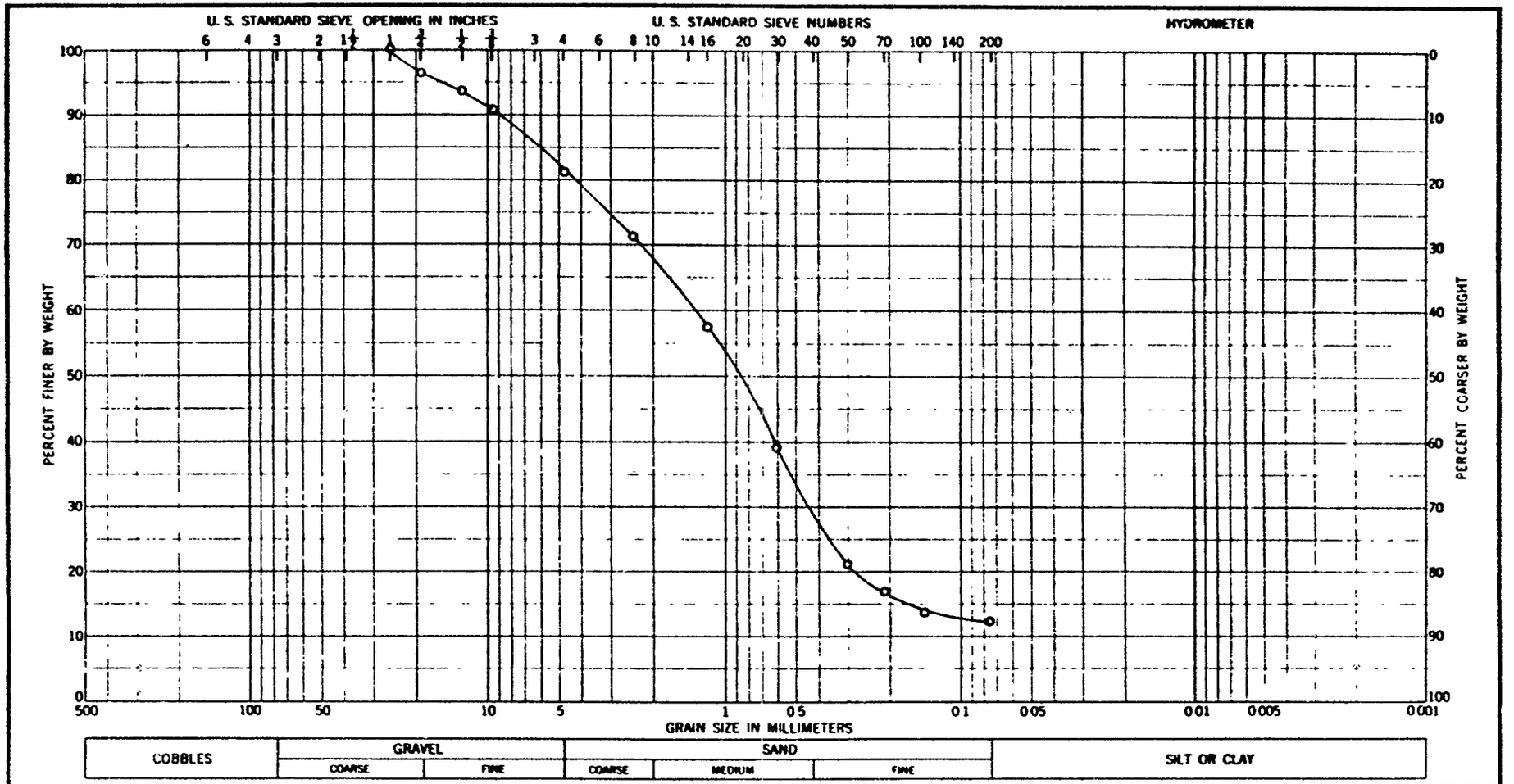
Sample No	Depth	Classification	D10	-#200
7	15.5-16.5	SC Gr. clayey sand	--	17.2%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-55
Date 27 September 1989

PLATE C-7

EN FORM 1 MAY 63 2087



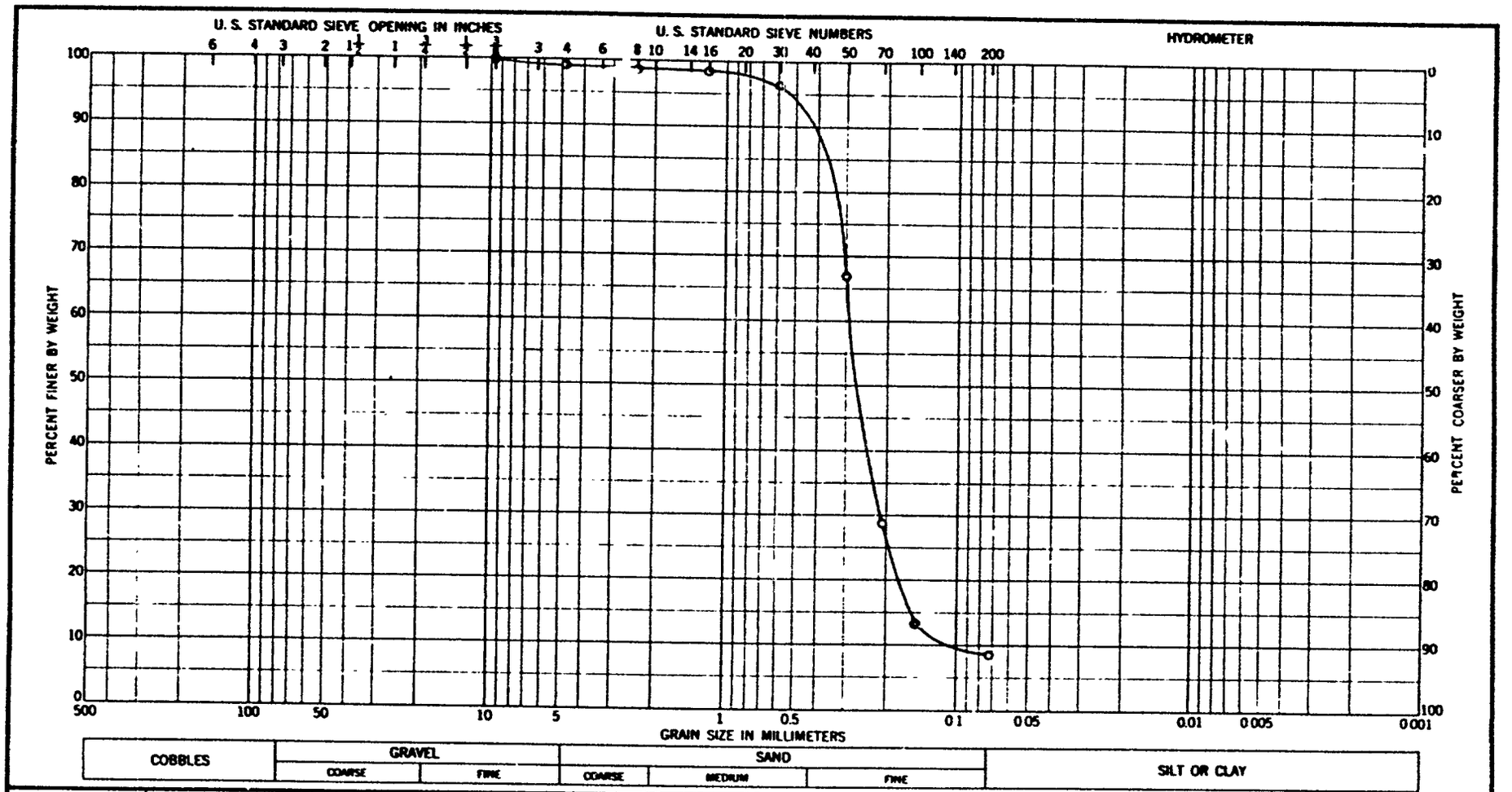
Sample No	Depth	Classification			D10	-#200
8	20.5-21.5	SC Gr. gravelly clayey sand			--	12.7%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No WDM-89-55
Date 27 September 1989

PLATE C-8

ENG FORM 1 MAY 63 2087



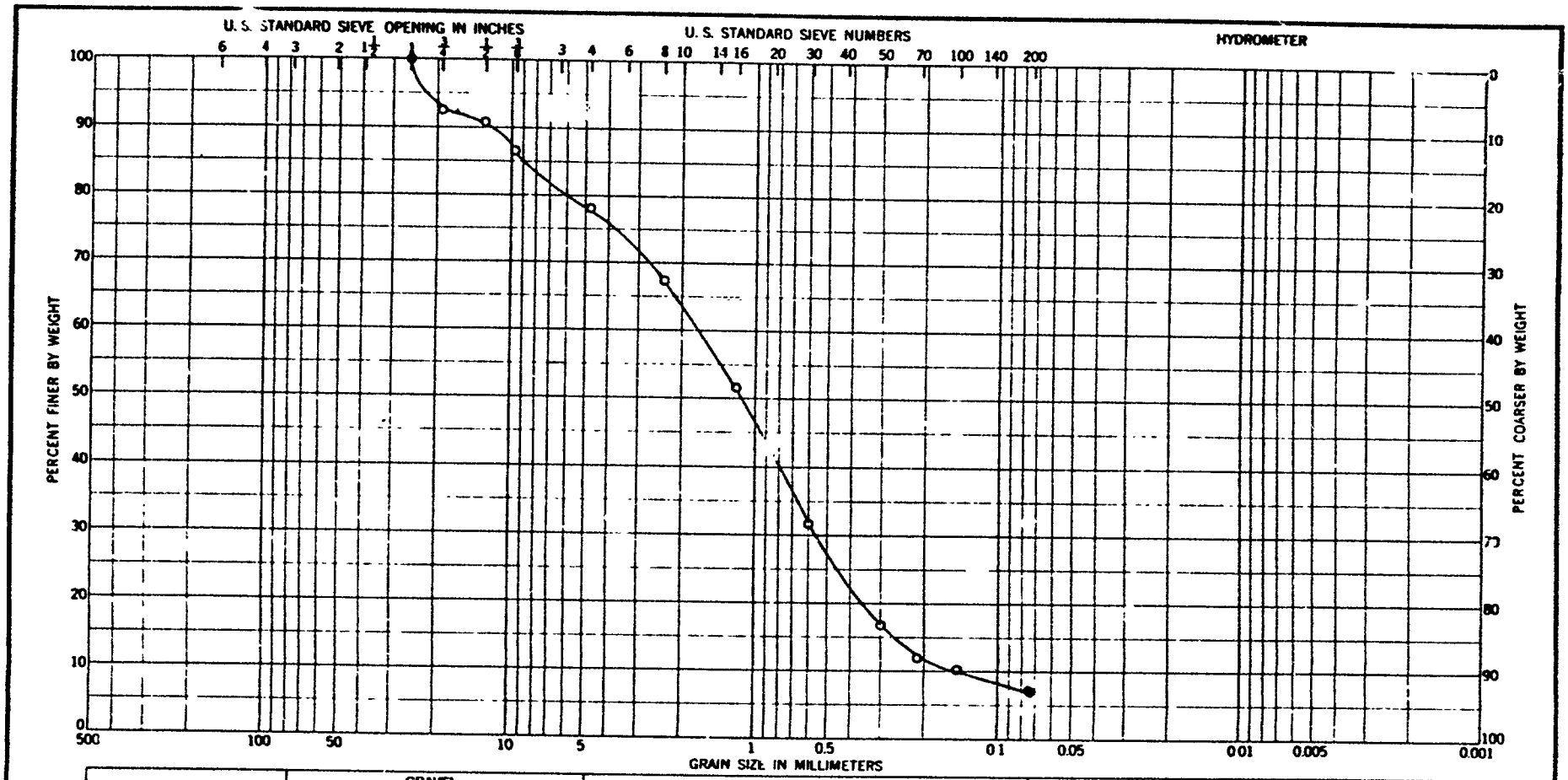
Sample No	Depth	Classification			D10	-#200
9	25.5-26.5	SP-SC Gr. clayey medium to fine sand			0.12	8.3%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IA
Area
Boring No. WDM-89-55
Date 27 September 1989

PLATE C-9

ENG FORM 1 MAY 63 2087



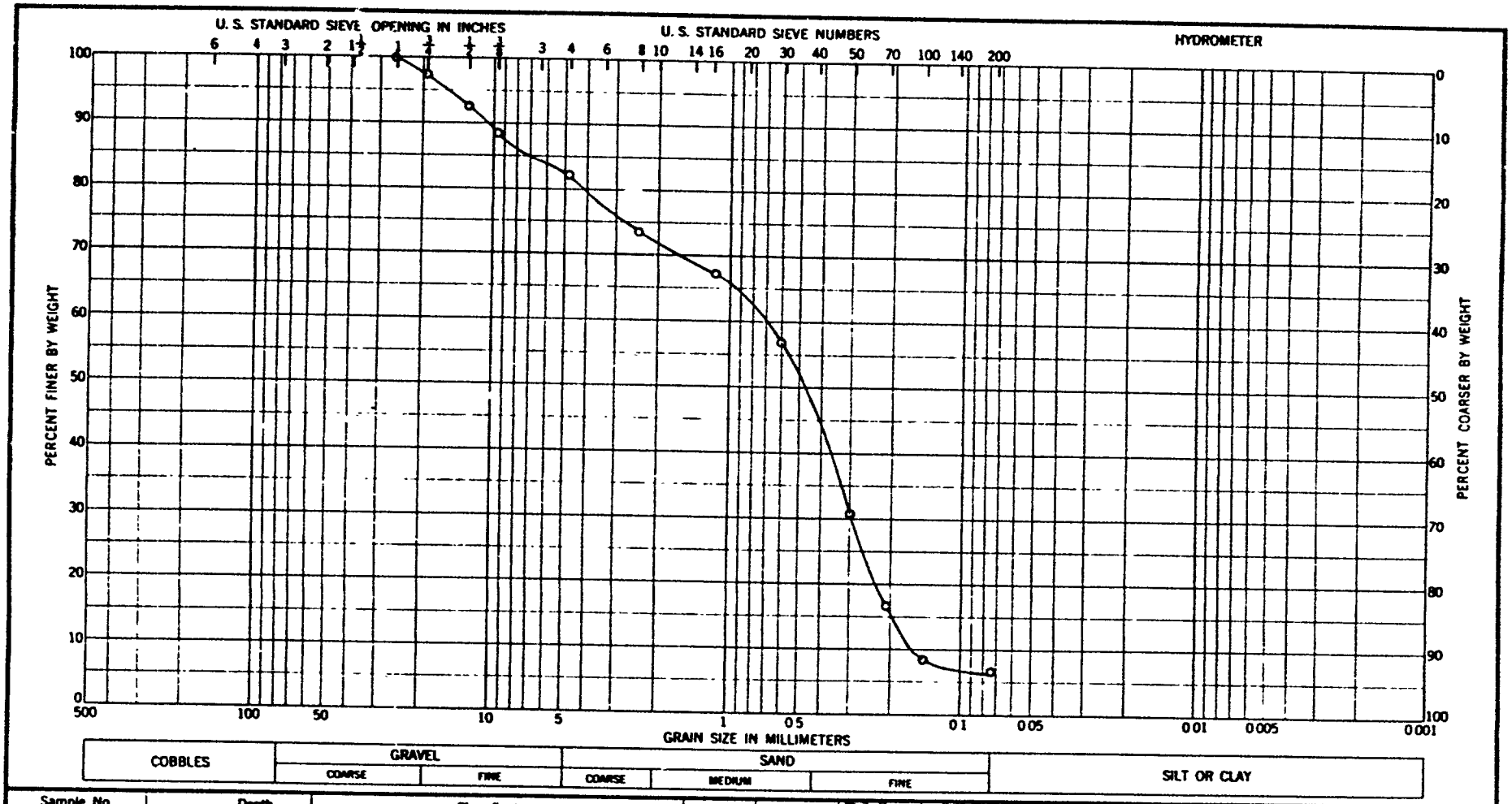
Sample No	Depth	Classification	D10	-#200
10	30.5-31.5	SW-SC Gr. clayey gravelly coarse to fine sand, with thin layer of clay	0.16	7.5%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-55
Date 27 September 1989

PLATE C-10

ENG FORM 1 MAY 63 2087



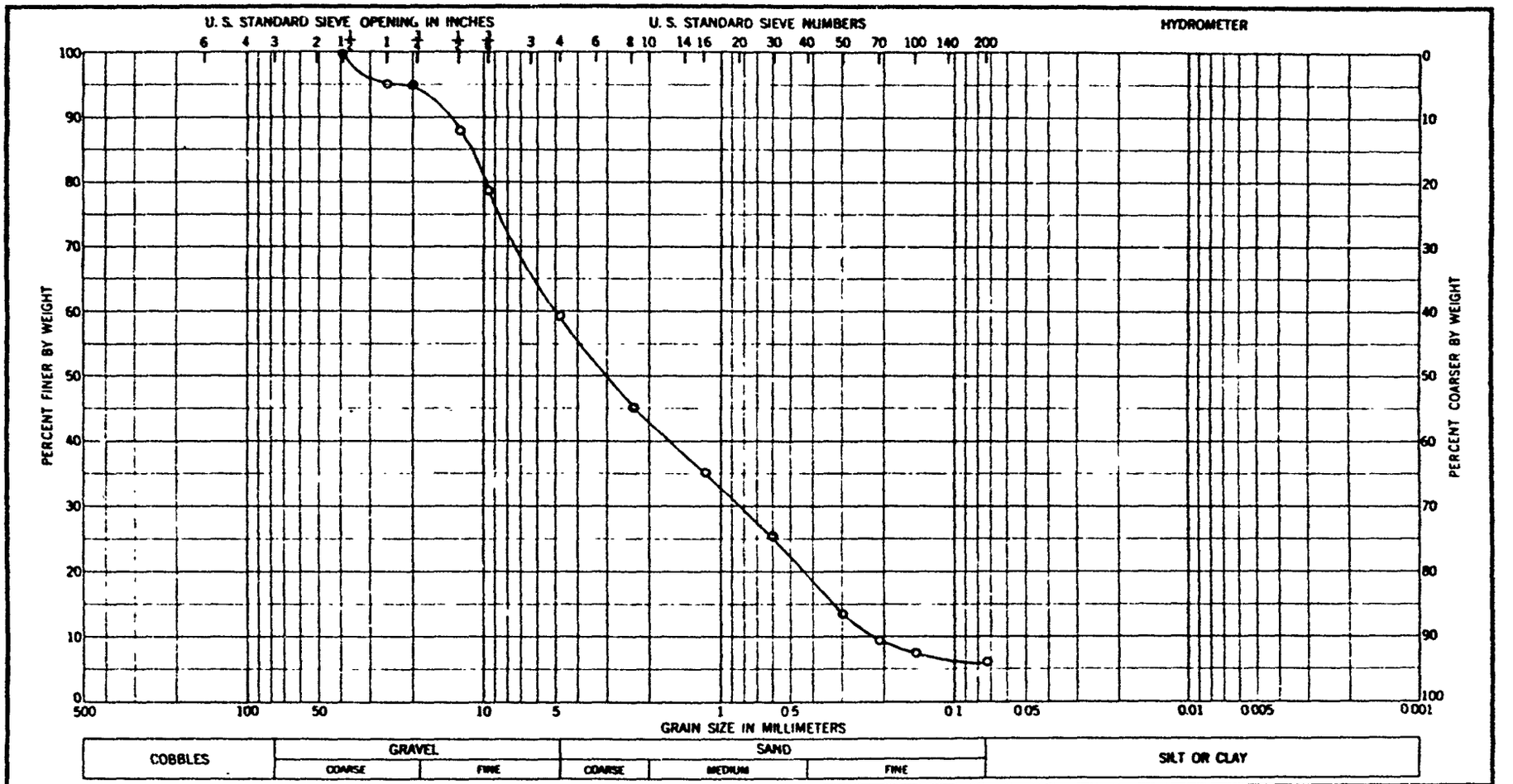
Sample No	Depth	Classification			D10	-#200
6	13.0-14.0	SP-SC Gr. clayey gravelly coarse to fine sand			0.17	6.2%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-58
Date 28 September 1989

PLATE C-11

ENG FORM MAY 63 2087



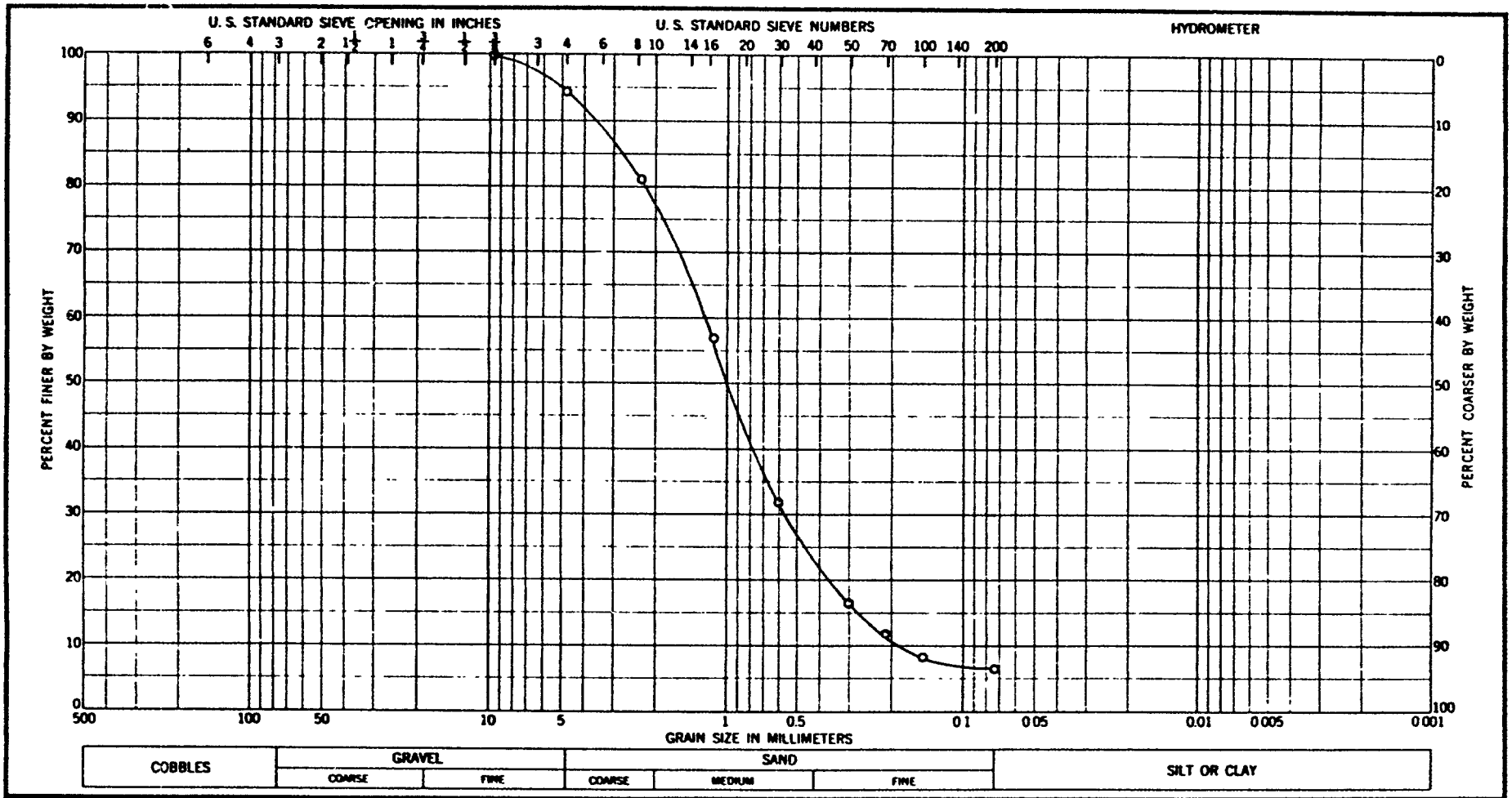
Sample No	Depth	Classification			D10	-#200
7	15.5-16.5	SP-SC Br. clayey gravelly coarse to fine sand			0.23	6.2%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES
Area
Boring No. WDM-89-58
Date 28 September 1989

PLATE C-12

ENG FORM 1 MAY 63 2087



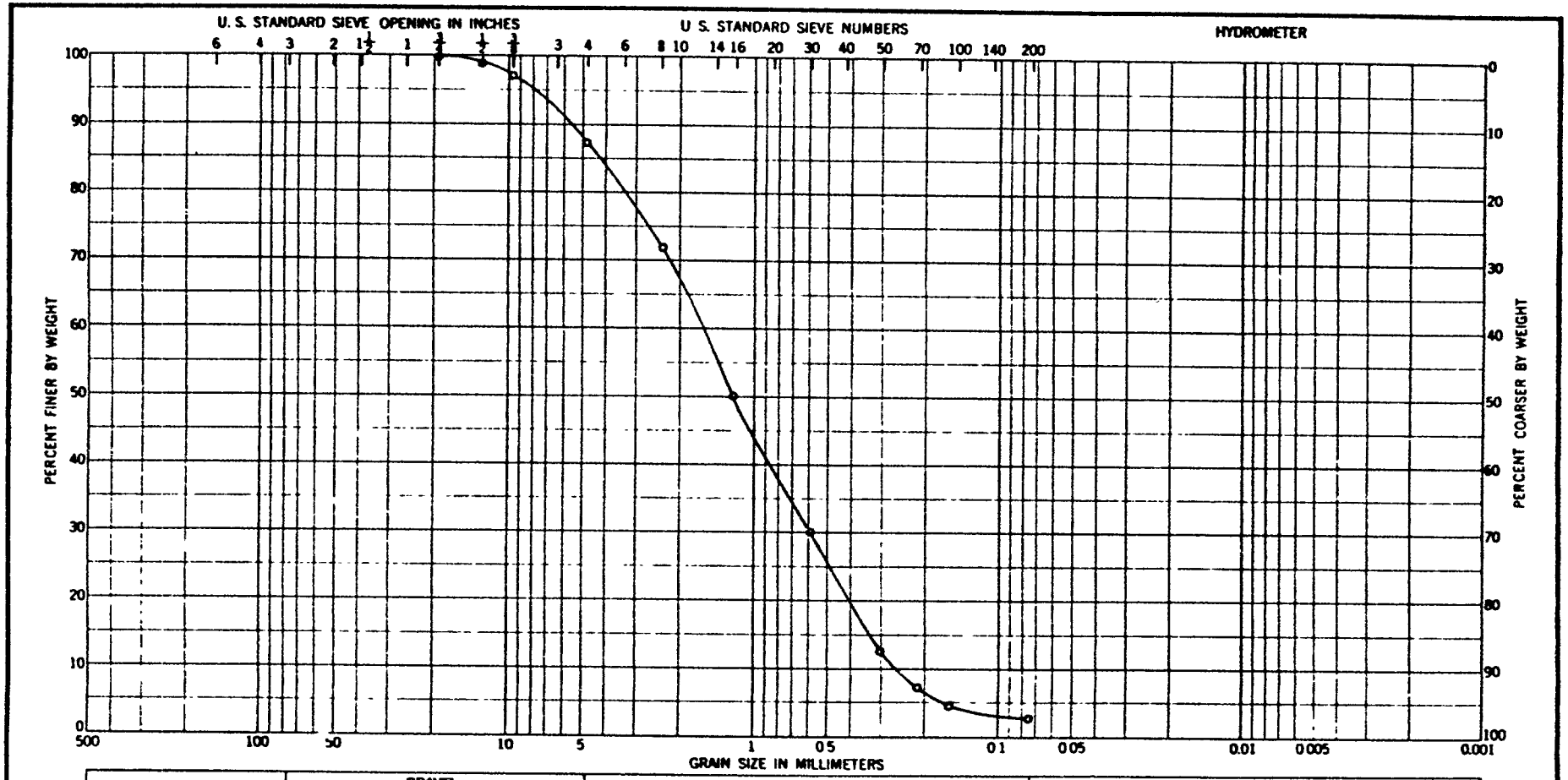
Sample No	Depth	Classification			D10	-#200
8	20.5-21.5	SP-SC Br. clayey coarse to sand, with gravel		fine	0.19	6.5%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES
Area
Boring No. WDM-89-58
Date 28 September 1989

PLATE C-13

ENG FORM 1 MAY 63 2087



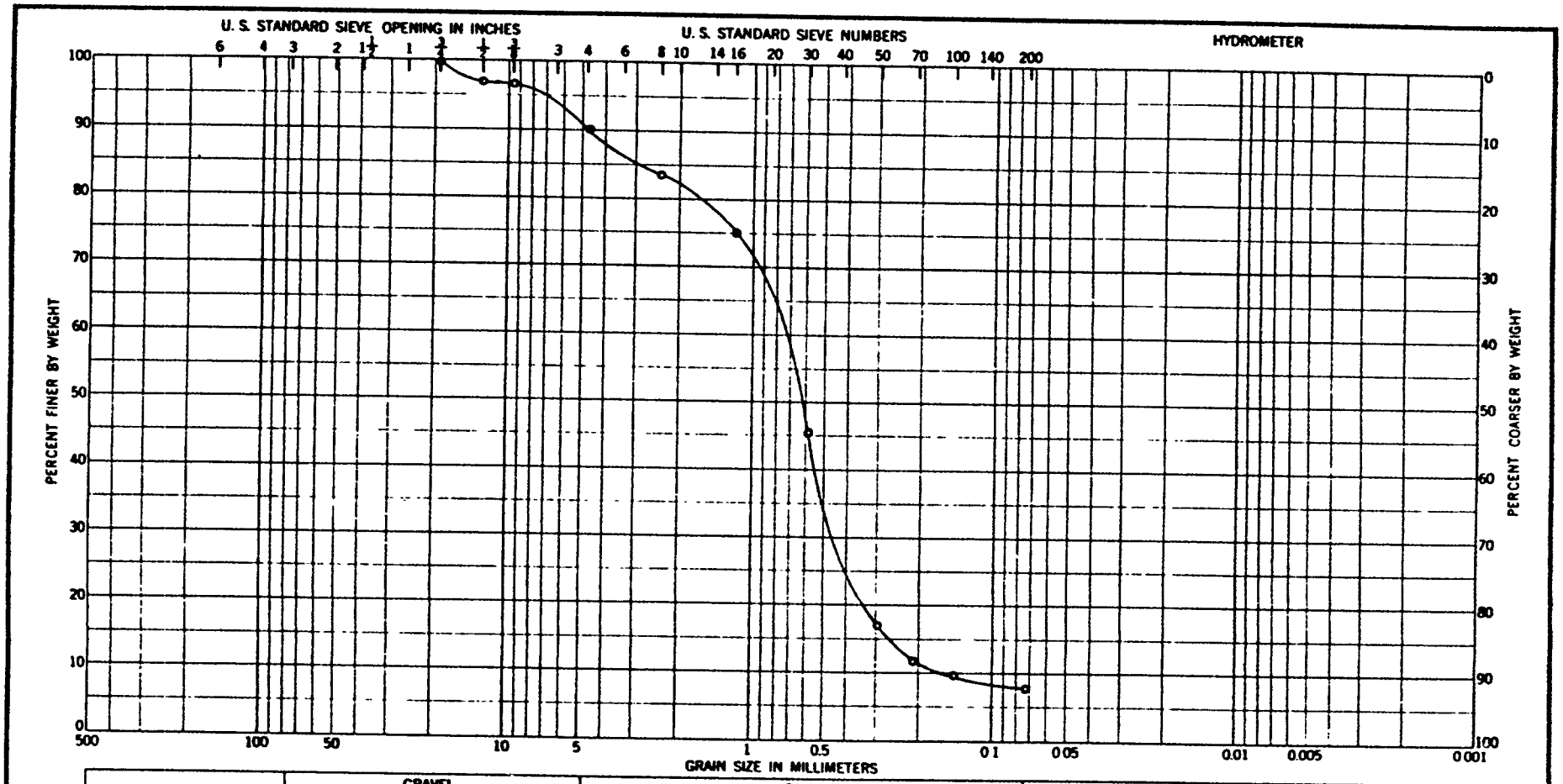
Sample No	Depth	Classification			D10	-#200
10	30.5-31.5	SP Gr. gravelly coarse to fine sand			0.27	3.3%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-58
Date 28 September 1989

PLATE C-14

ENG FORM 1 MAY 63 2087



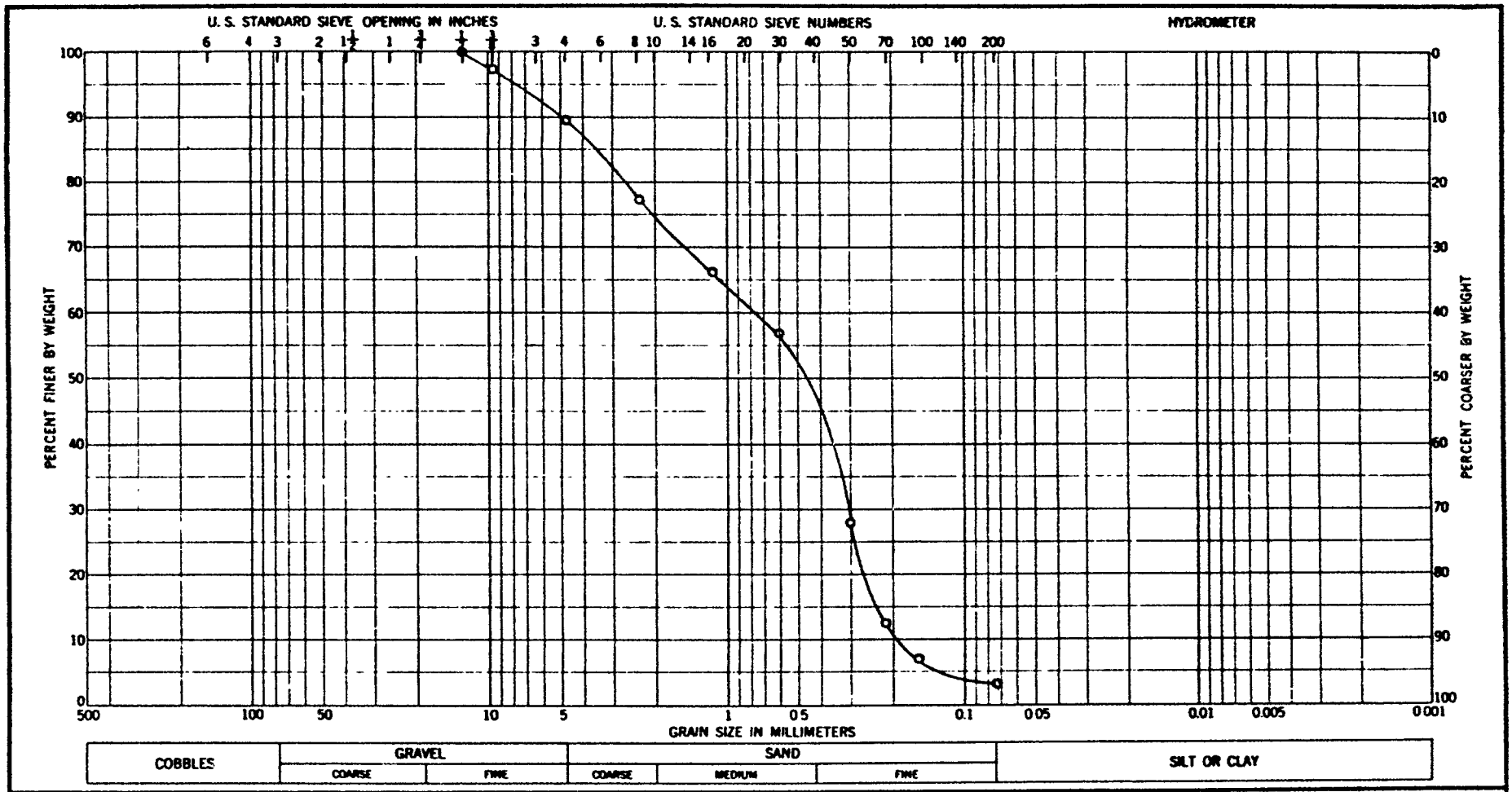
Sample No	Depth	Classification			D10	-#200
11	35.5-36.5	SP-SC Gr. clayey gravelly to fine sand med.			0.17	7.7%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Borng No. WDM-89-58
Date 28 September 1989

PLATE C-15

ENG FORM MAY 63 2087



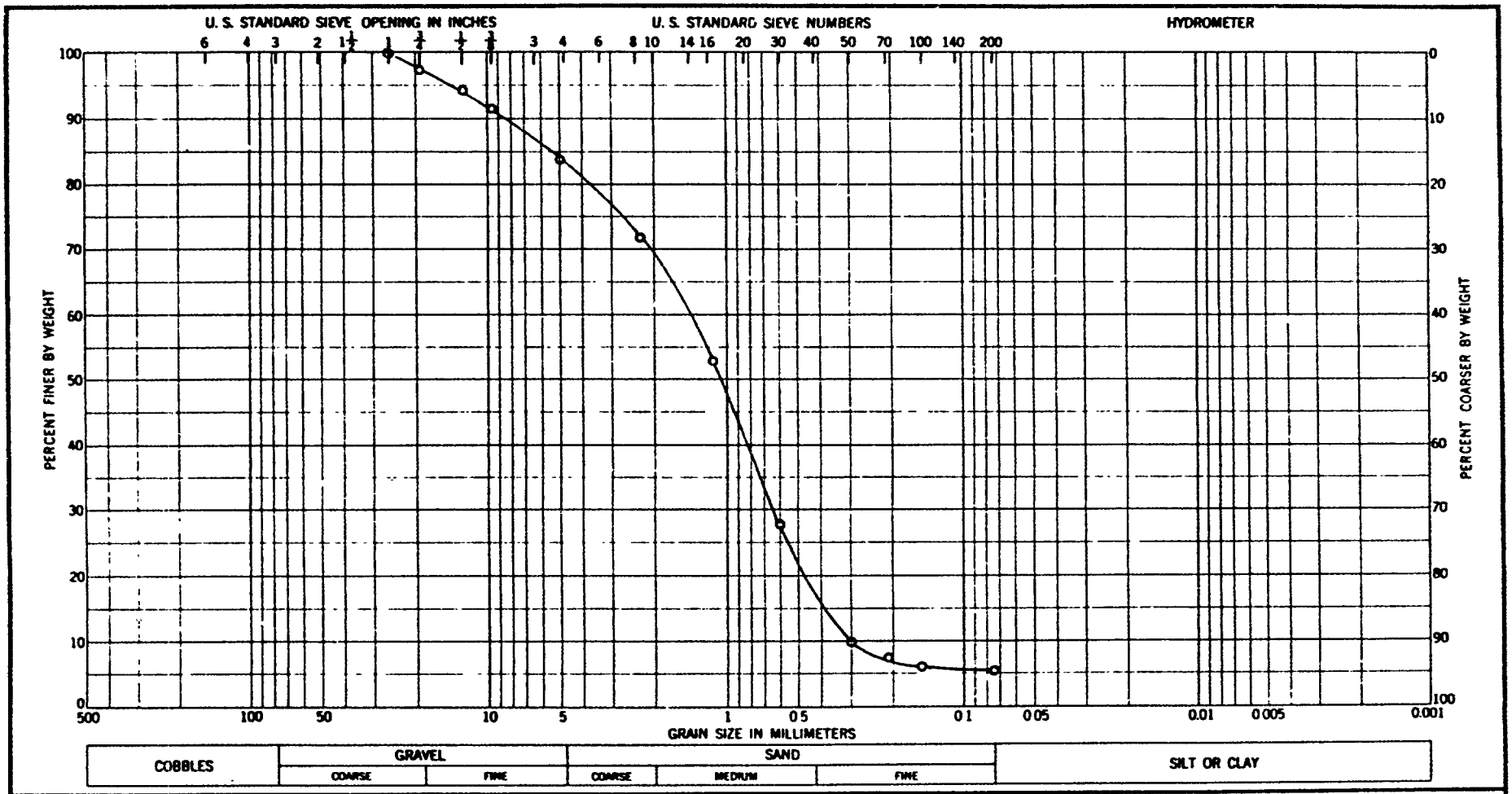
Sample No.	Depth	Classification			D10	-#200
5	10.5-11.2	SP Br. gravelly coarse sand	to	fine	0.20	4.2%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-67
Date 3 October 1989

PLATE C-16

ENG FORM 1 MAY 63 2087



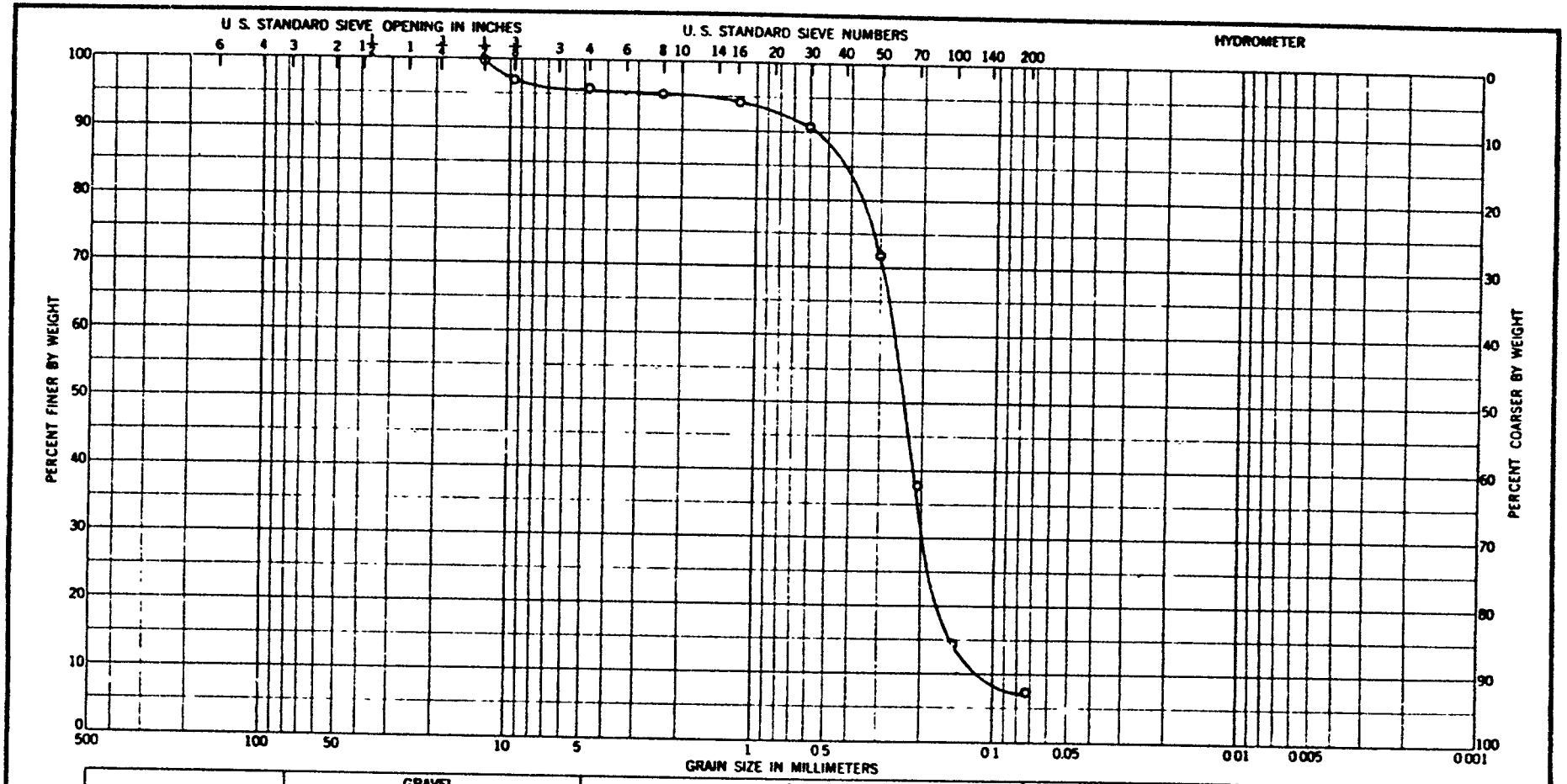
Sample No	Depth	Classification			D10	-#200
7	15.5-16.5	SP-SC Br. clayey gravelly coarse to fine sand			0.30	5.3%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-67
Date 3 October 1989

PLATE C-17

ENG FORM MAY 63 2087



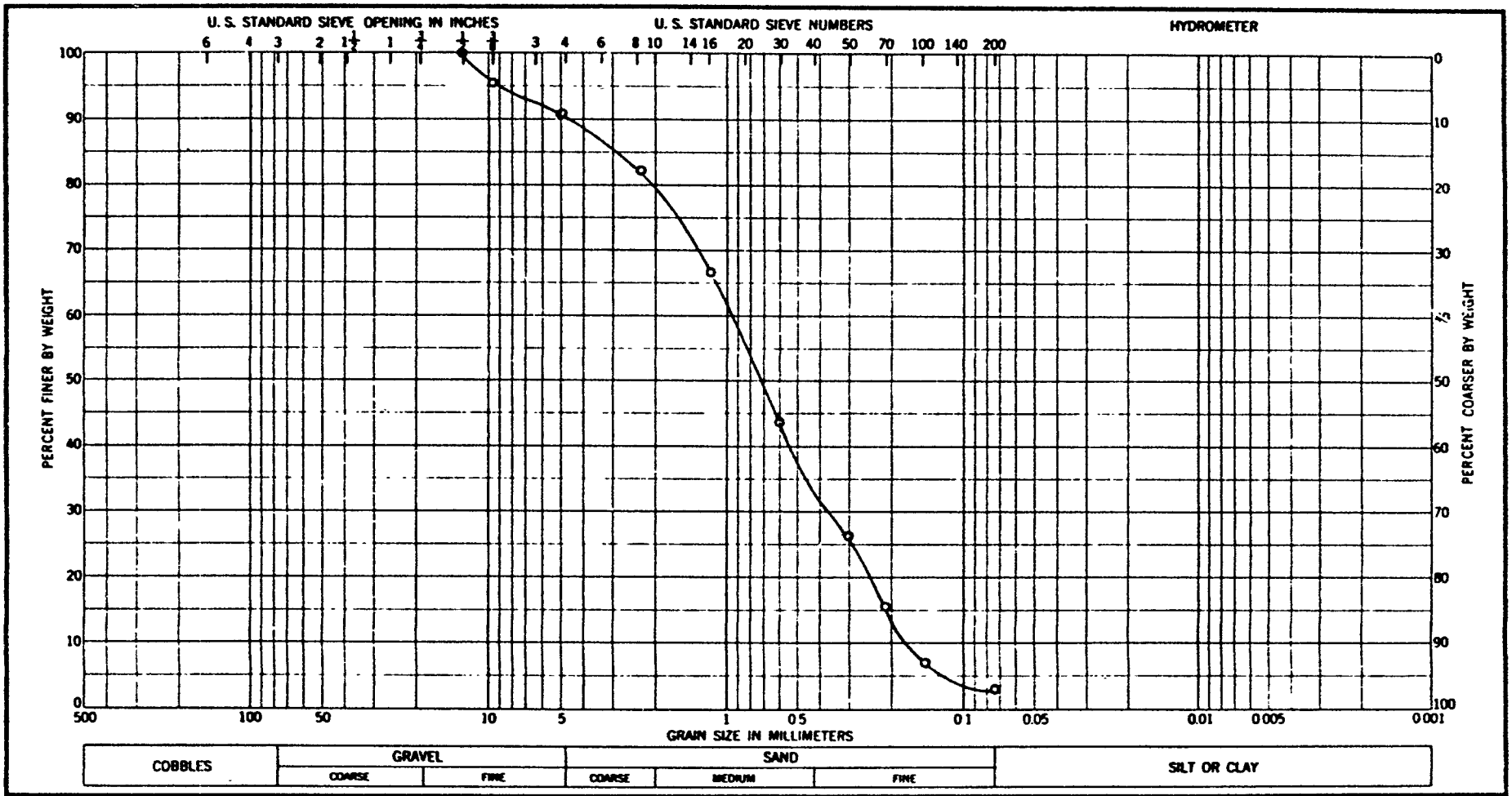
Sample No	Depth	Classification			D10	-#200
9	25.5-26.5	SP-SC Gr. clayey medium to sand, trace gravel		fine	0.12	7.0%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-67
Date 3 October 1989

PLATE C-18

ENG FORM 1 MAY 63 2087



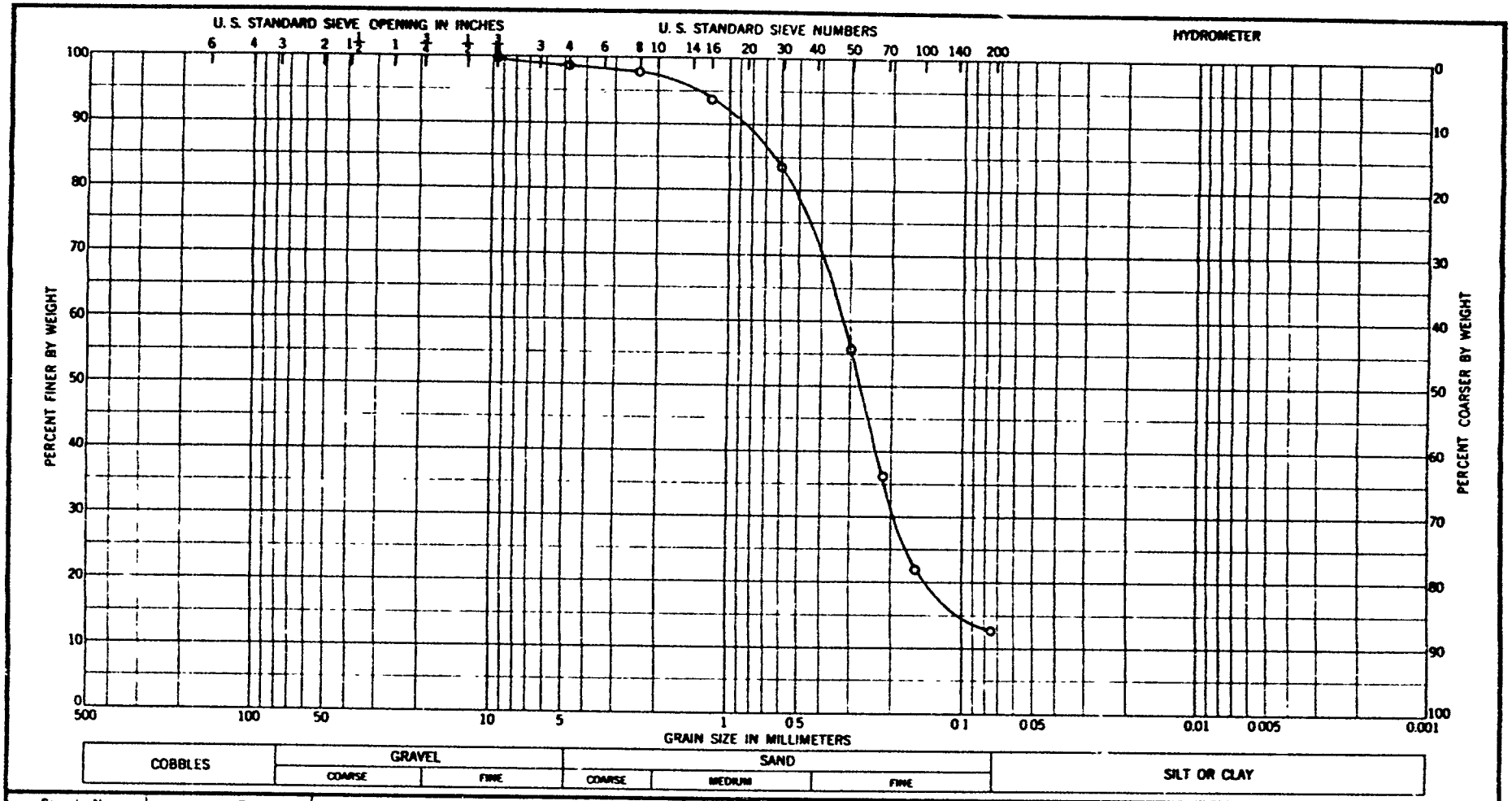
Sample No	Depth	Classification			D10	-#200
10	30.5-31.5	SP Gr. coarse to fine gravel	sand,	with	0.18	3.5%

GRADATION CURVES

Project: WEST DES MOINES
DES MOINES, IOWA
Area:
Boring No.: WDM-89-67
Date: 3 October 1989

PLATE C-19

ENG FORM MAY 63 2087



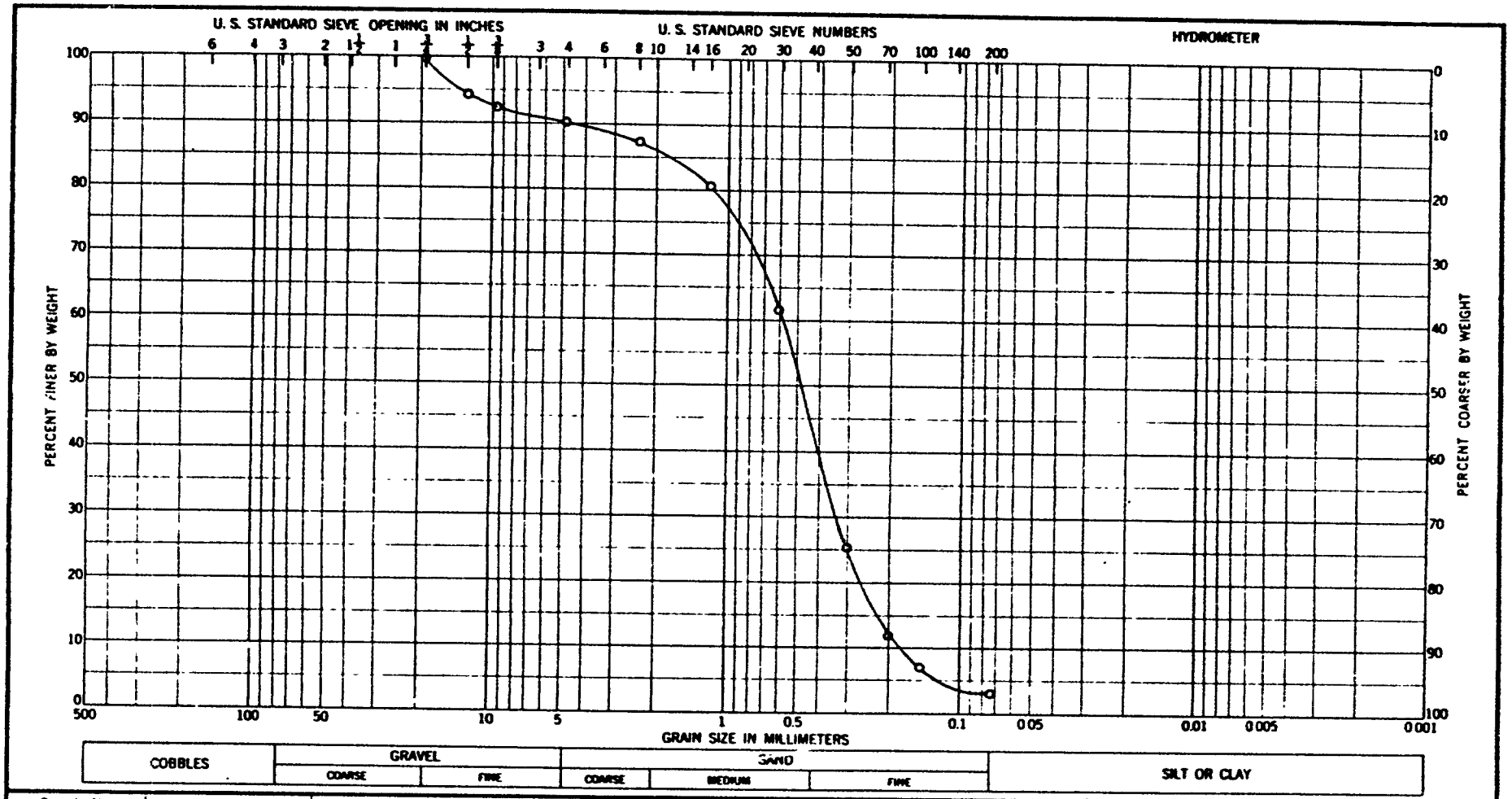
Sample No.	Depth	Classification			D10	-#200
11	35.5-36.5	SC Gr. clayey sand			--	12.7%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IA
Area
Boring No. WDM-89-67
Date 3 October 1989

PLATE C-20

ENG FORM 1 MAY 63 2087



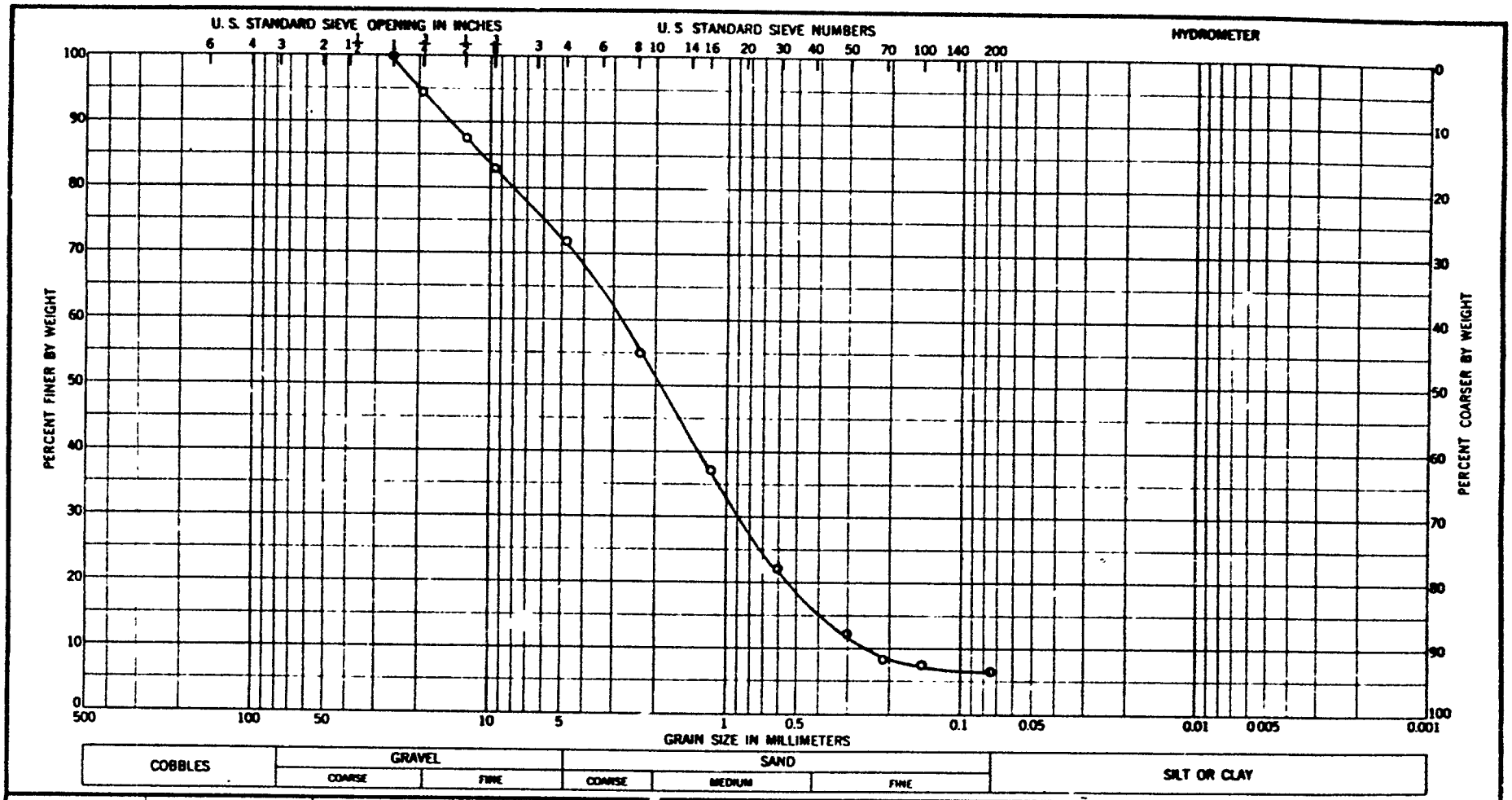
Sample No	Depth	Classification	D10	-#200
7	15.5-16.0	SP Reddish Br. medium to fine sand, with gravel	0.18	4.2%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-70
Date 4 October 1989

PLATE C-21

ENG FORM MAY 63 2087



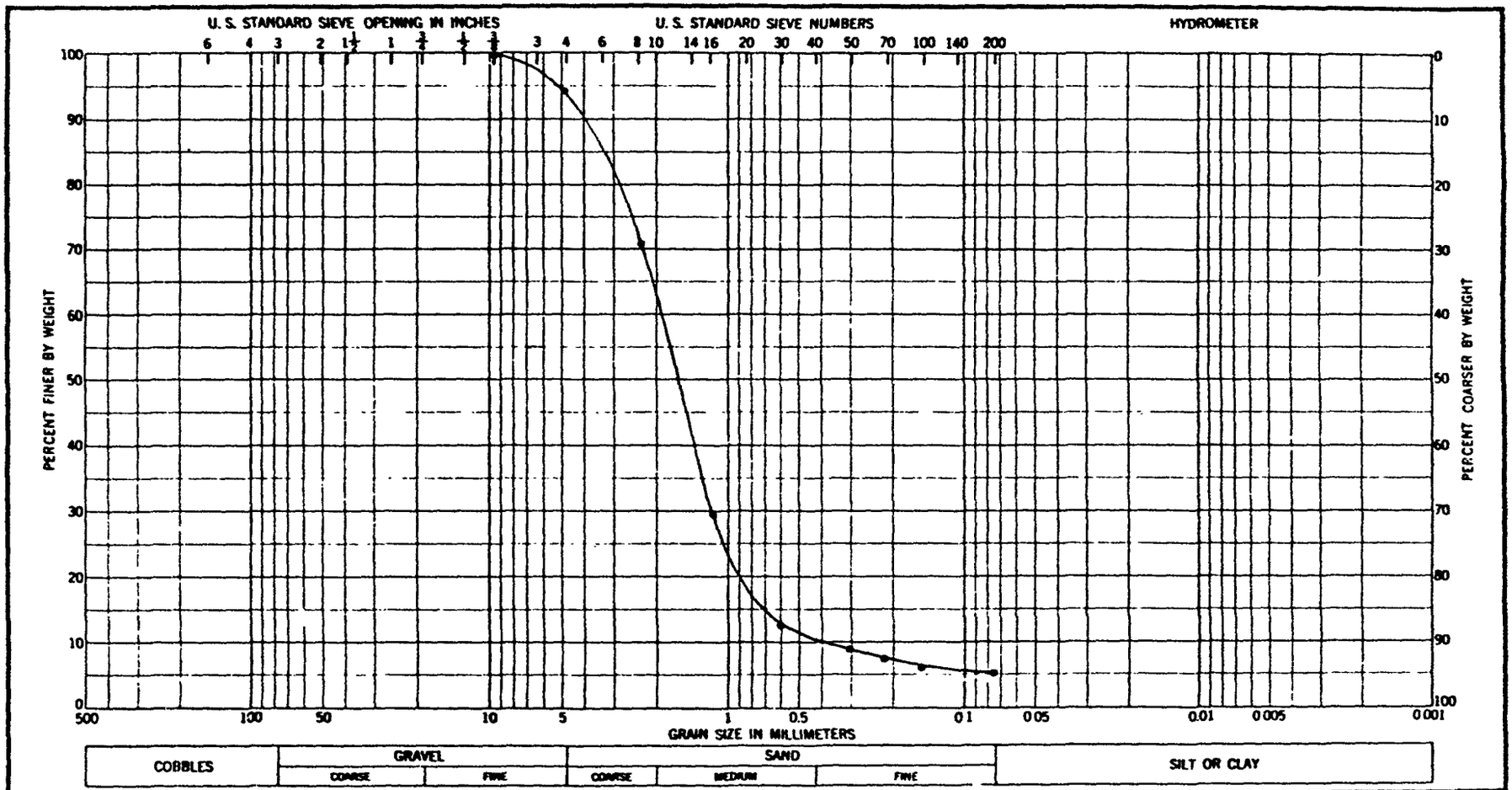
Sample No	Depth	Classification	D10	-#200
8	20.5-21.5	SW-SC Br. clayey gravelly coarse to fine sand	0.26	6.7%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-70
Date 4 October 1989

PLATE C-22

ENG FORM 1 MAY 63 2087



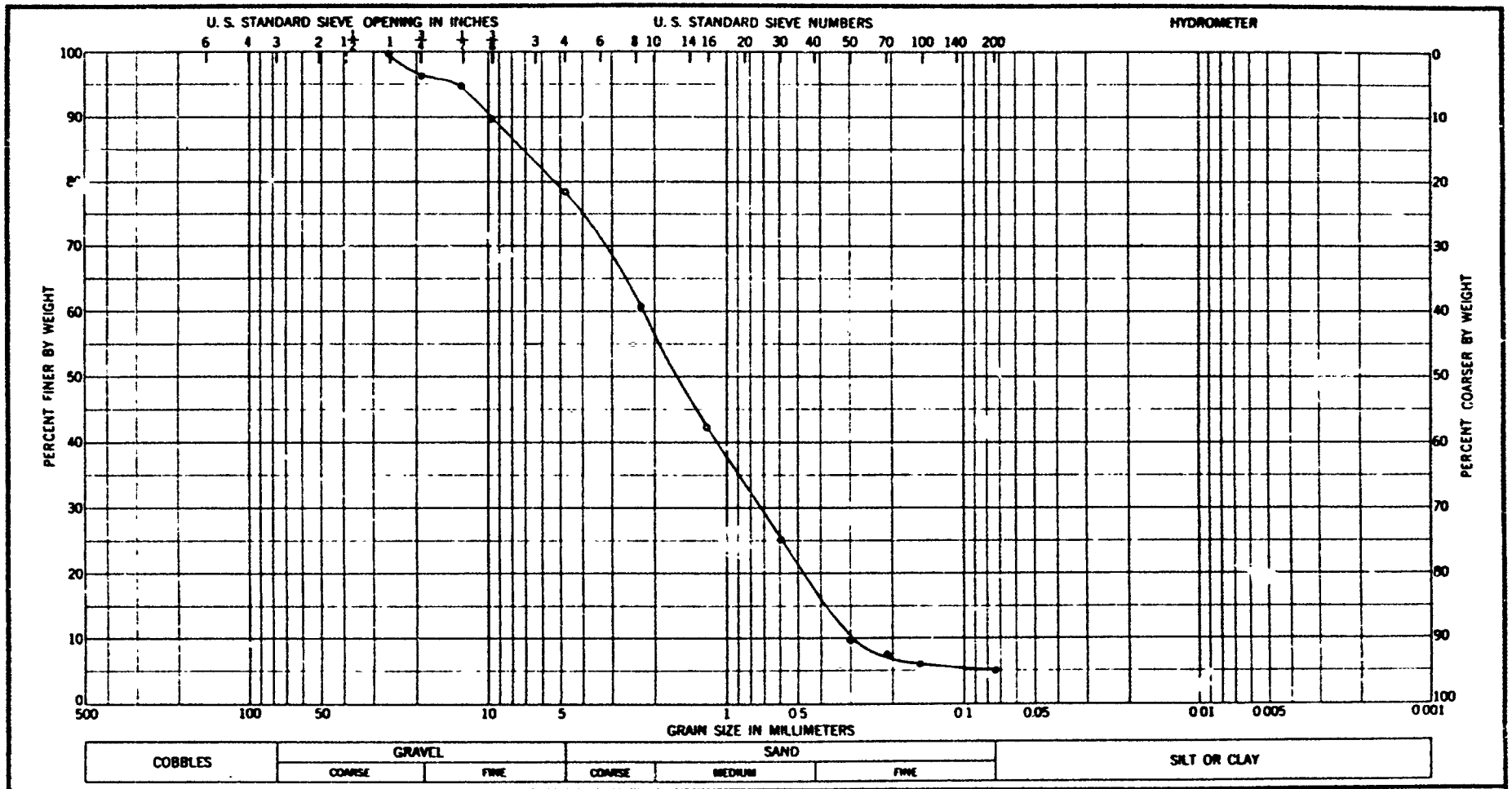
Sample No	Depth	Classification	D10	-#200
9	25.5-26.5	SP-SC Gr. clayey coarse to medium sand, with gravel	0.40	5.1%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No WDM-89-70
Date 4 October 1989

PLATE C-23

ENG FORM MAY 63 2087



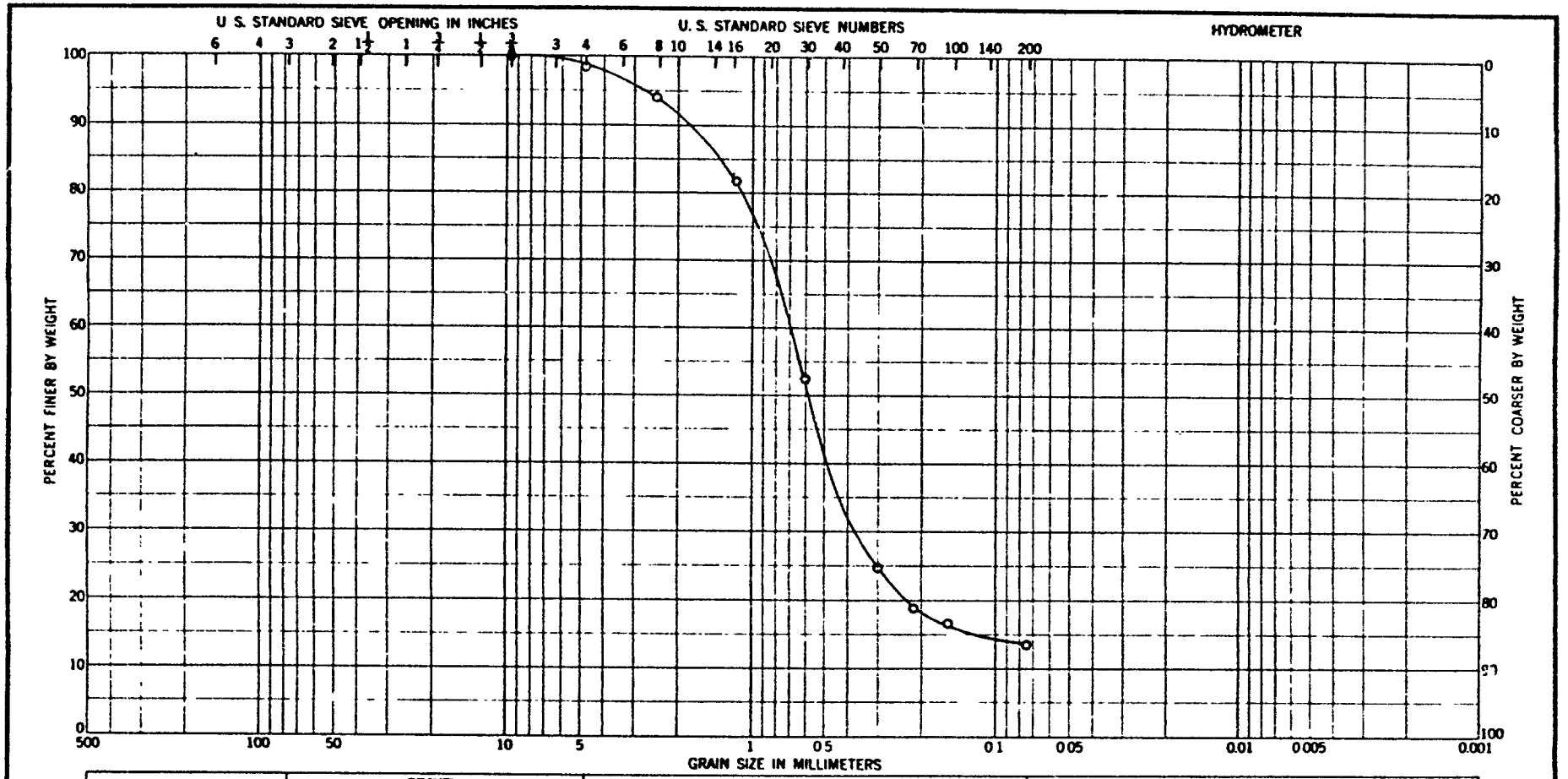
Sample No.	Depth	Classification			D10	-#200
10	30.5-31.5	SP-SC Gr. clayey gravelly coarse to fine sand			0.30	5.4%

GRADATION CURVES

Project: WEST DES MOINES
DES MOINES, IOWA
Area:
Boring No.: WDM-89-70
Date: 4 October 1989

PLATE C-24

ENG FORM 1 MAY 63 2087



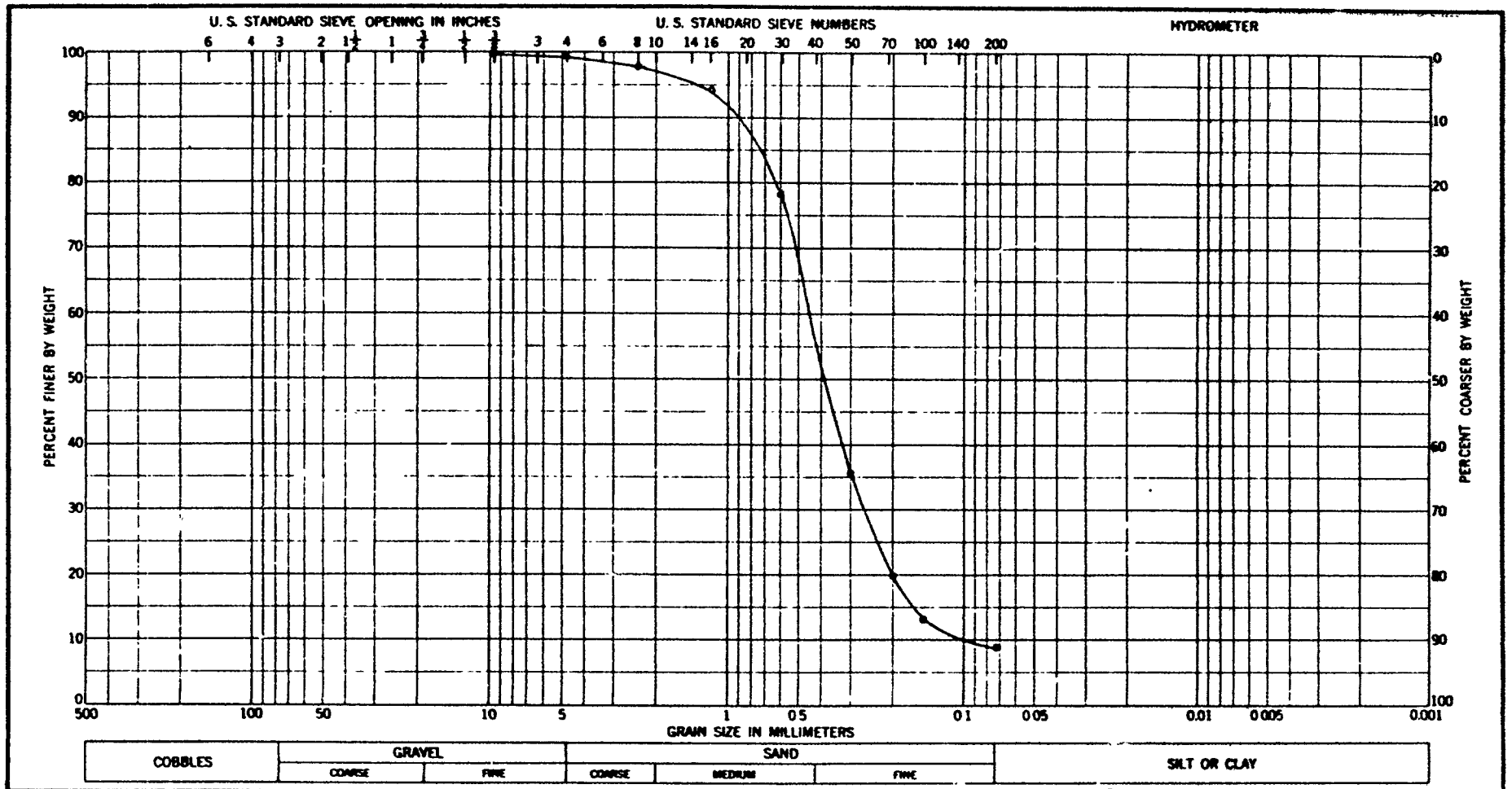
Sample No	Depth	Classification			D10	-#200
11	35.5-36.5	SC Gr. clayey sand, trace wood			--	14.0%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No WDM-89-70
Date 4 October 1989

PLATE C-25

ENG FORM 1 MAY 63 2087



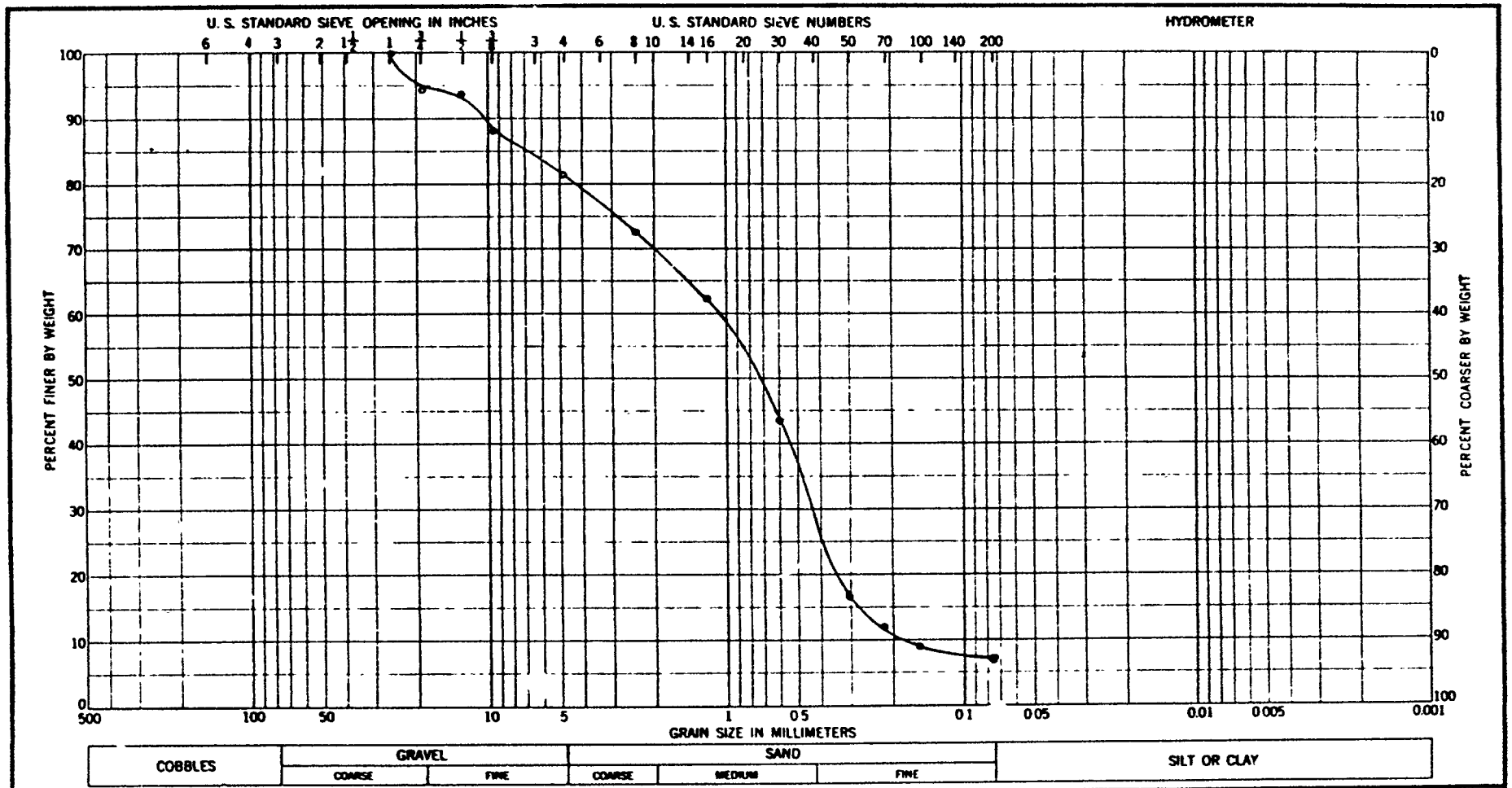
Sample No	Depth	Classification			D10	-#200
12	40.5-41.5	SP-SC Gr. clayey medium to sand, trace wood		fine	0.10	9.1%

GRADATION CURVES

Project: WEST DES MOINES
DES MOINES, IOWA
Area:
Boring No.: WDM-89-70
Date: 4 October 1989

PLATE C-26

ENG FORM 1 MAY 63 2087

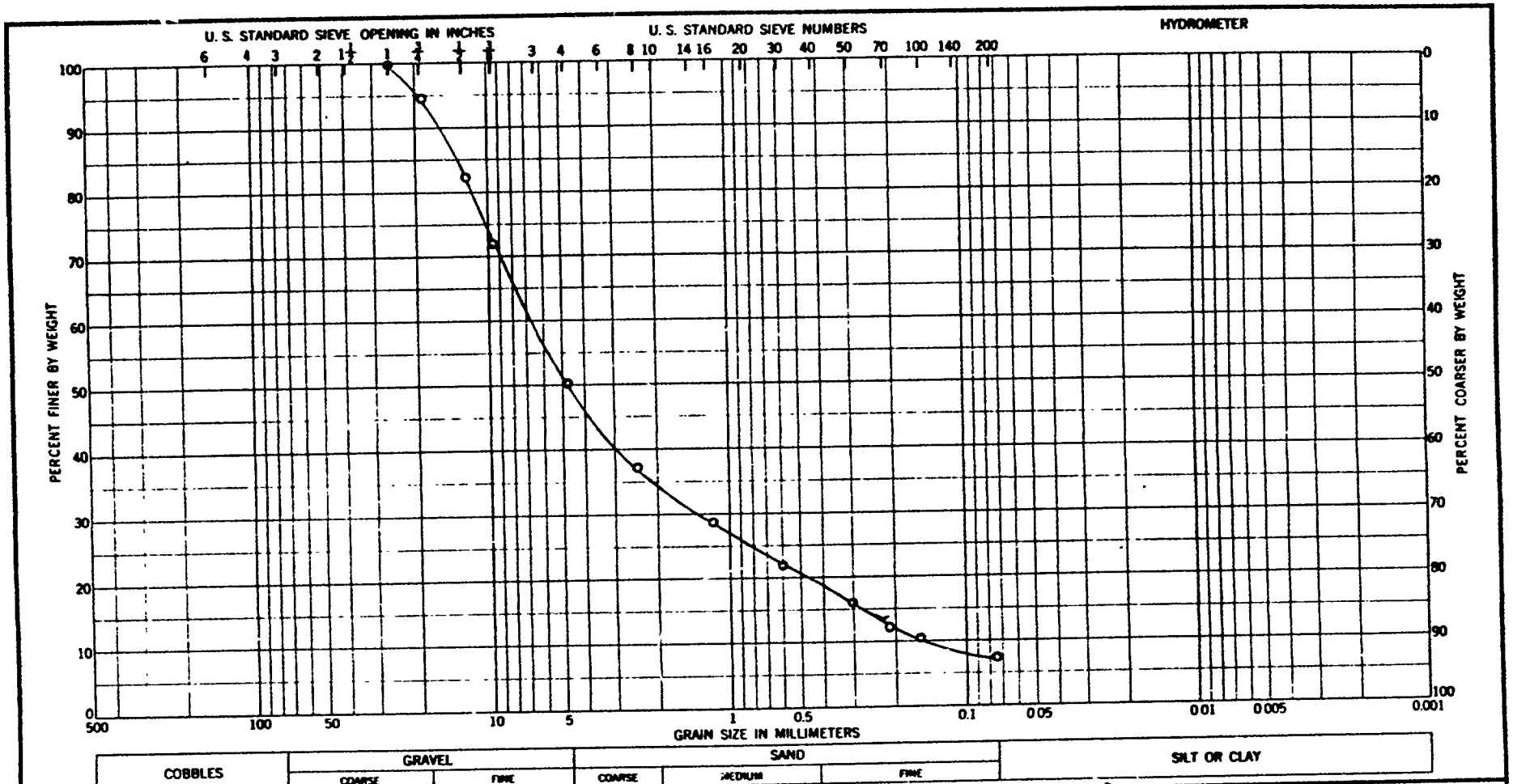


Sample No	Depth	Classification			D10	-#200
6	13.0-14.0	SP-SC Br. clayey gravelly coarse to fine sand			0.19	7.1%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-72
Date 5 October 1989

PLATE C-27



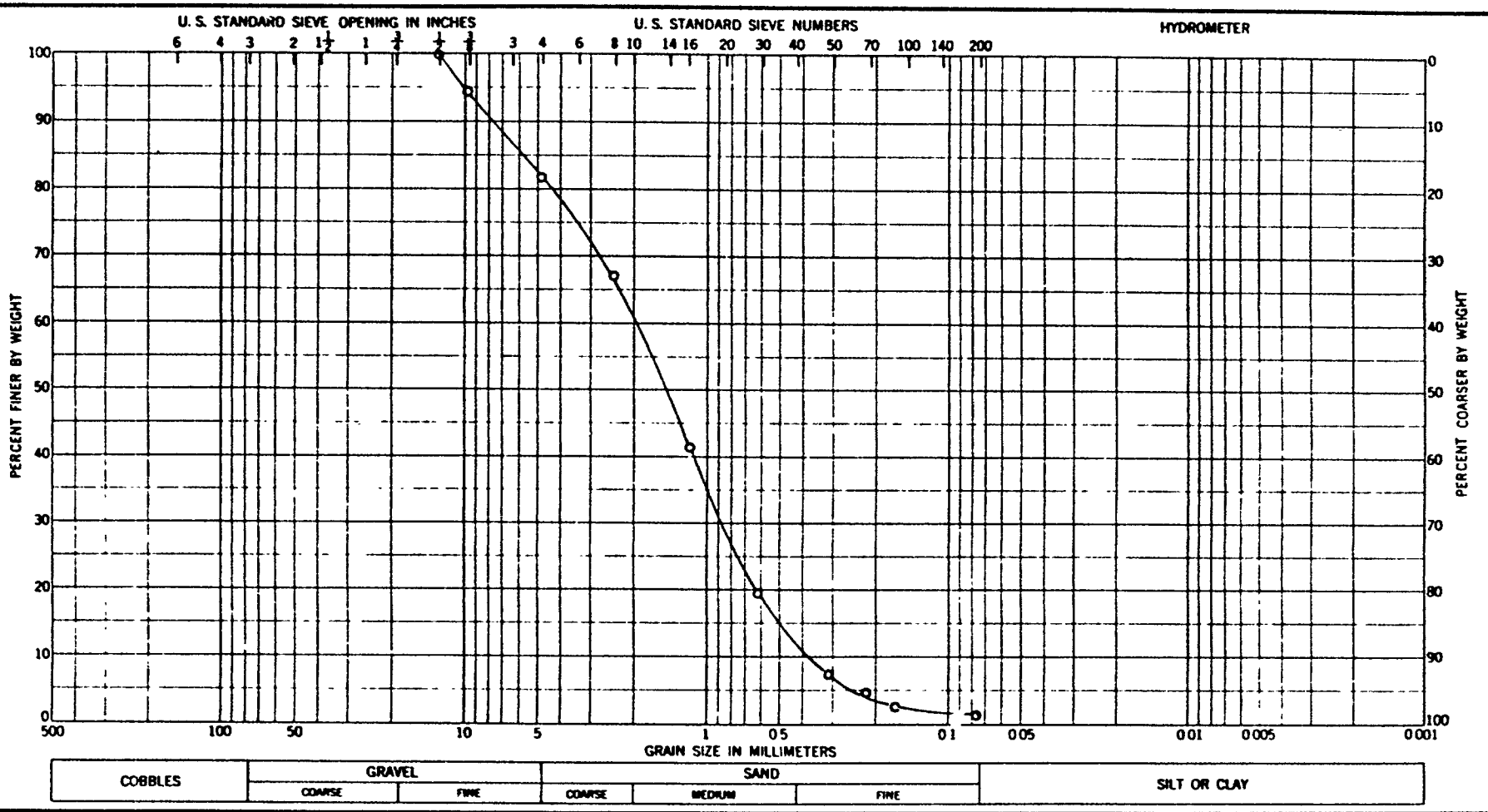
Sample No	Depth	Classification			D10	-#200
7	15.5-16.5	SW-SC Br. clayey gravelly coarse to fine sand			0.16	7.7%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-72
Date 5 October 1989

PLATE C-28

ENG FORM 1 MAY 63 2087



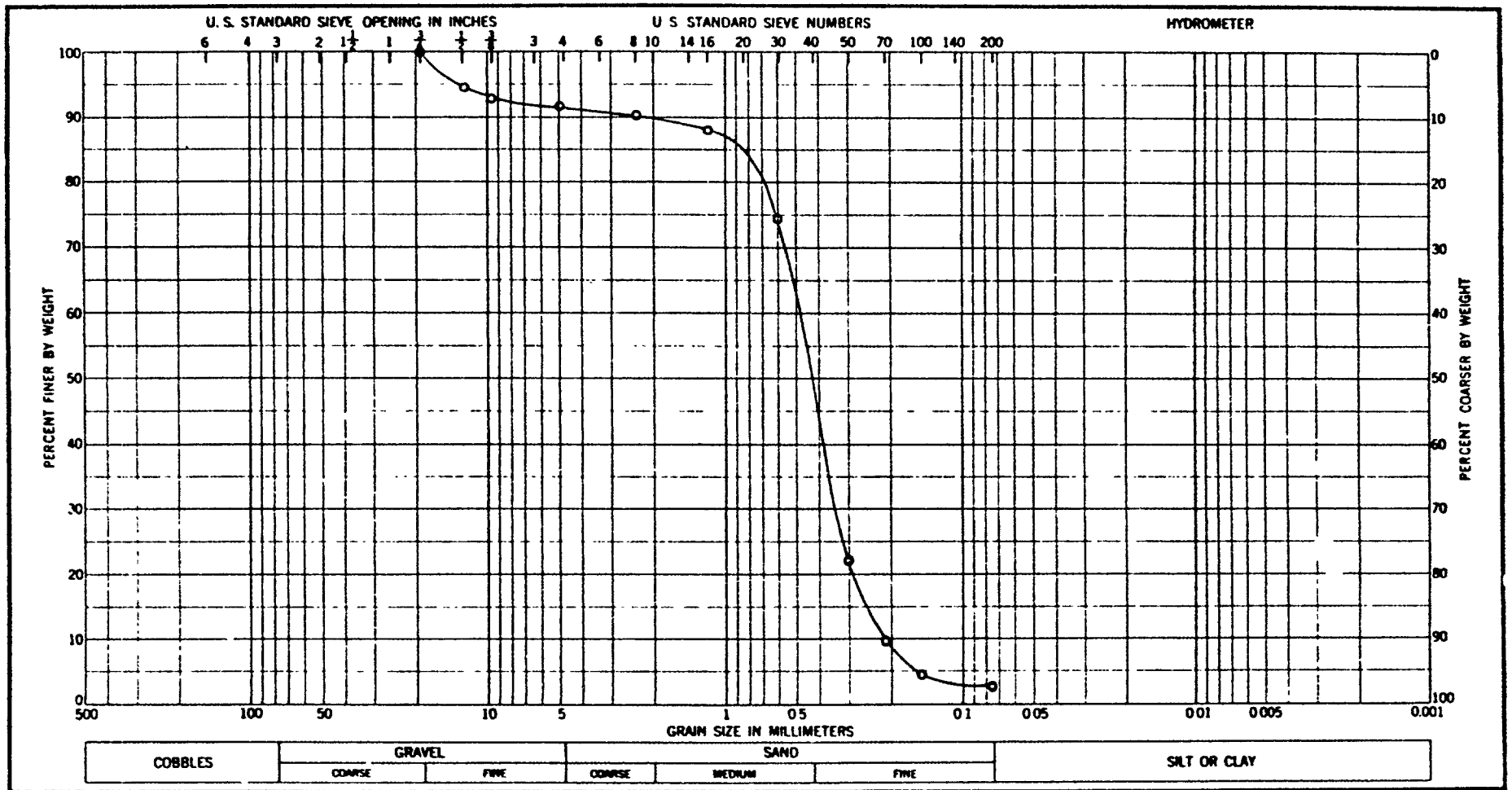
Sample No	Depth	Classification			D10	-#200
8	20.5-21.5	SP Br. gravelly coarse to fine sand			0.38	2.3%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-72
Date 5 October 1989

PLATE C-29

ENG FORM 4AY 63 2087



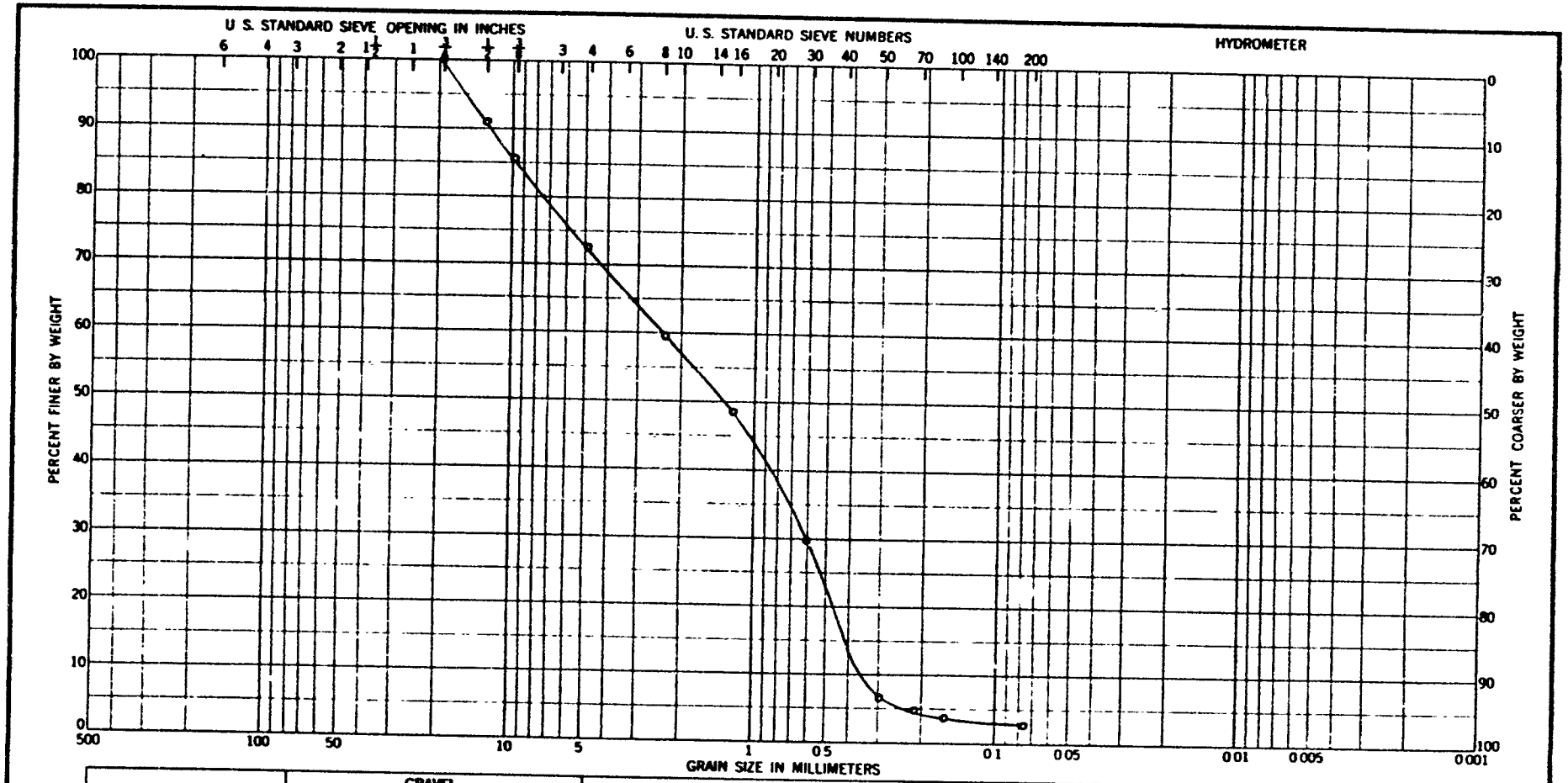
Sample No	Depth	Classification			D10	-#200
9	25.5-26.5	SP Gr. medium to fine gravel, trace coal	sand, with	and wood	0.22	3.1%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Borng No. WDM-89-72
Date 5 October 1989

PLATE C-30

ENG FORM 1 MAY 63 2087



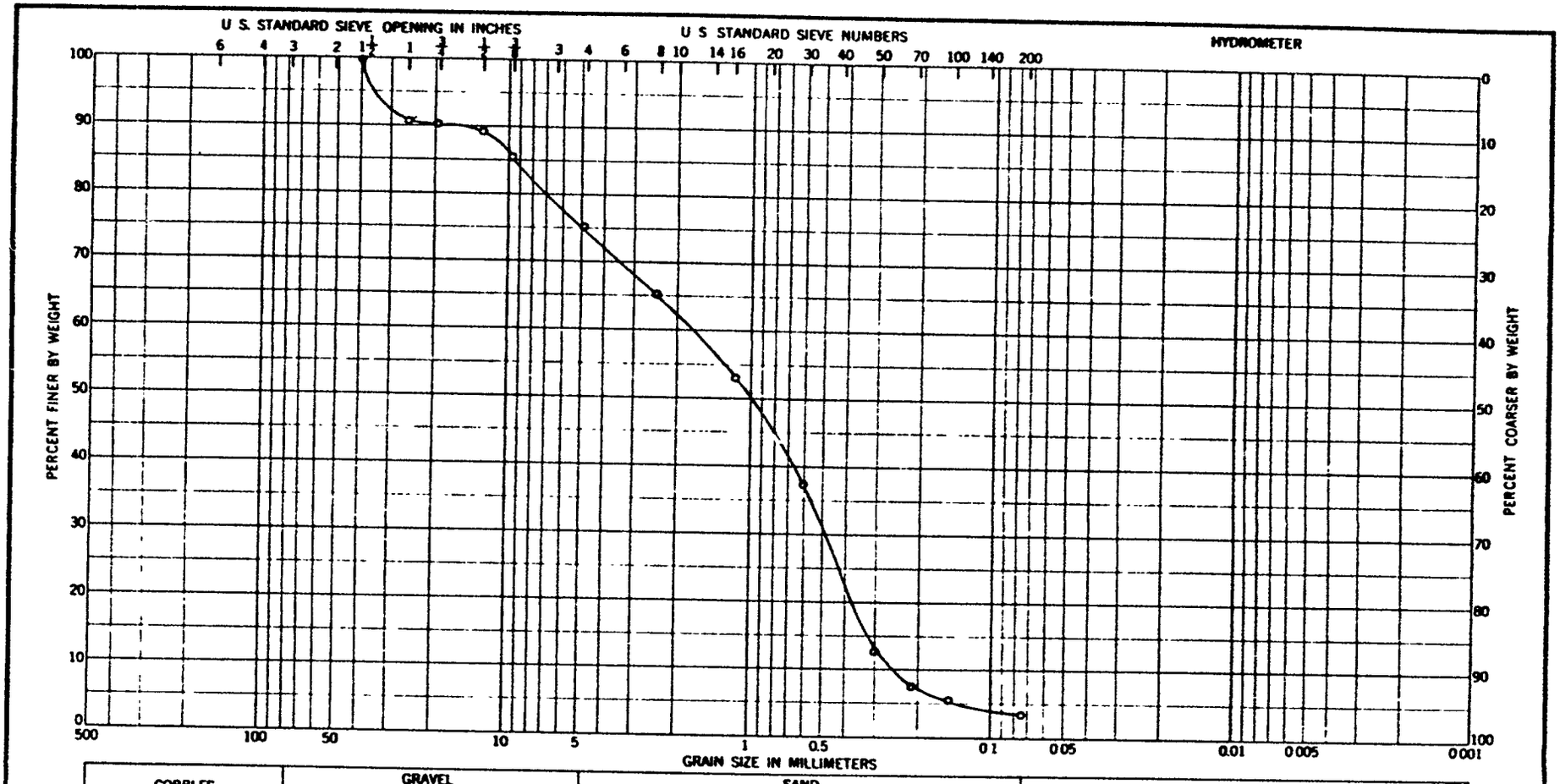
Sample No	Depth	Classification			D10	-#200
12	40.5-41.5	SP Gr. gravelly coarse to fine sand			0.36	2.9%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No WDM-89-72
Date 5 October 1989

PLATE C-31

ENG FORM MAY 63 2087



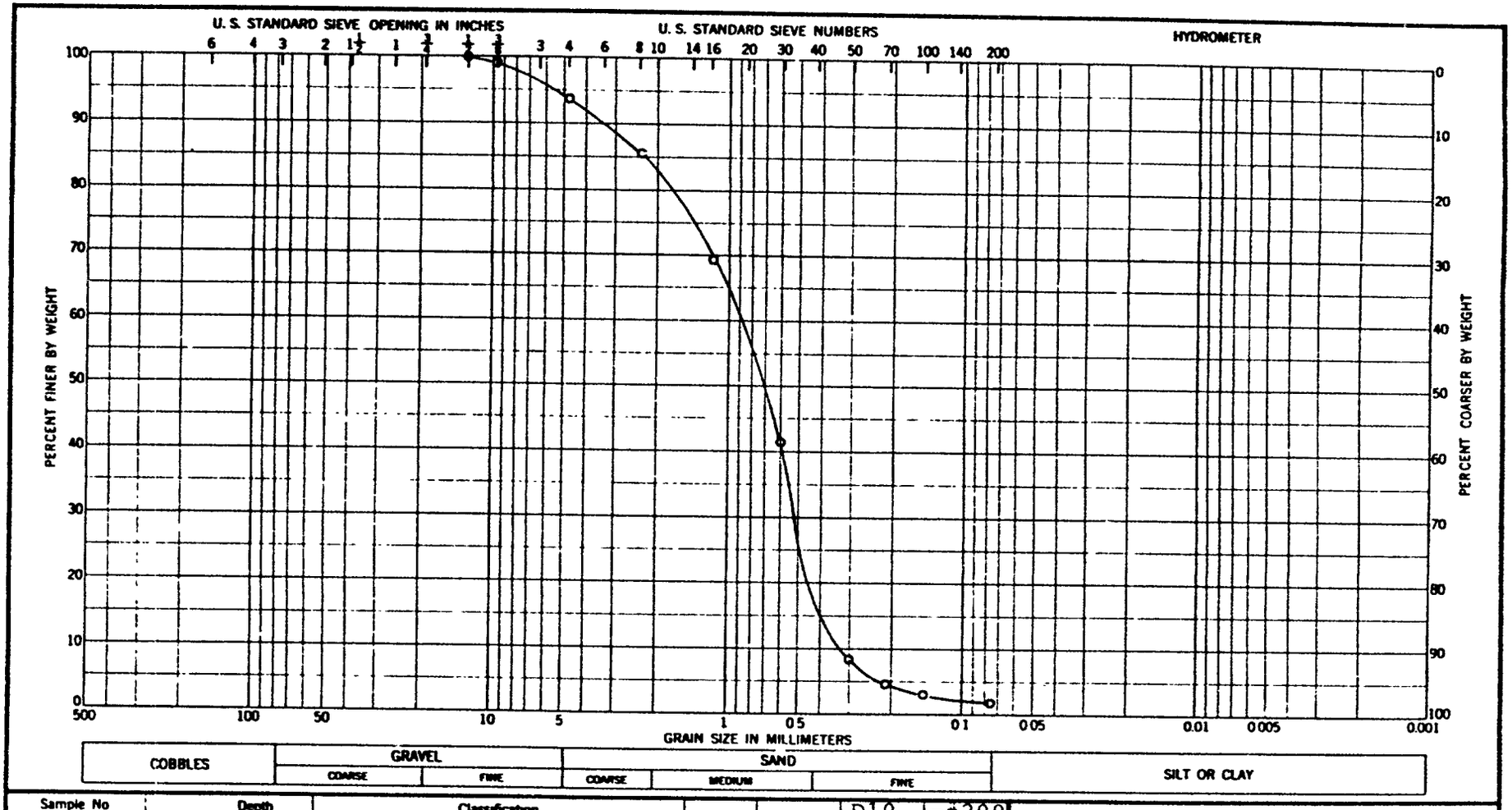
Sample No.	Depth	Classification			D10	-#200
8	20.5-21.5	SP Br. gravelly coarse to fine Sand			0.25	3.8%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No WDM-89-75
Date 10 October 1989

PLATE C-32

ENG FORM 1 MAY 63 2087



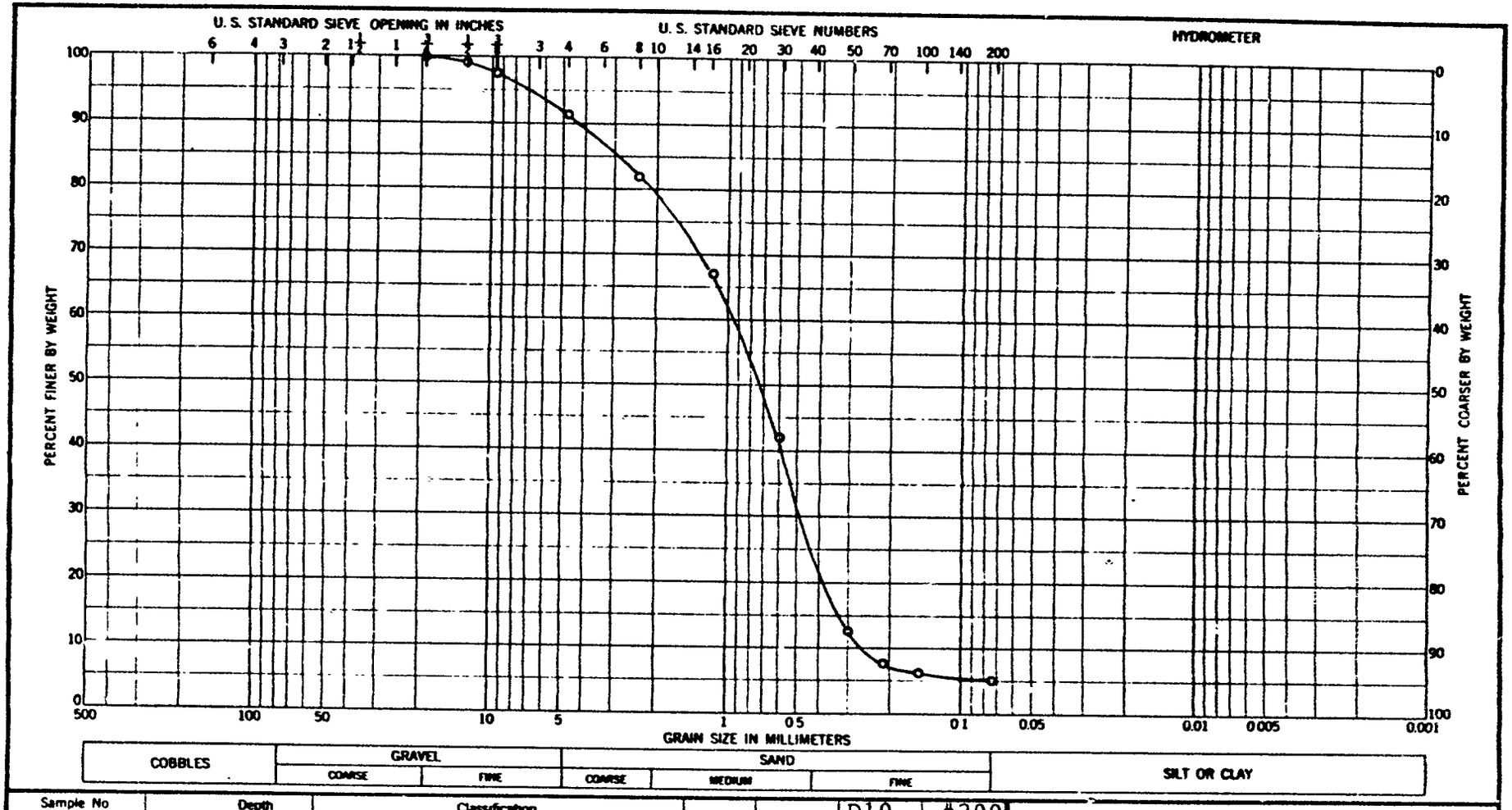
Sample No	Depth	Classification			D10	-#200
7	15.5-16.5	SP Br. coarse to fine with gravel	sand,		0.34	2.9%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-78
Date 10 October 1989

PLATE C-33

ENG FORM 1 MAY 63 2087



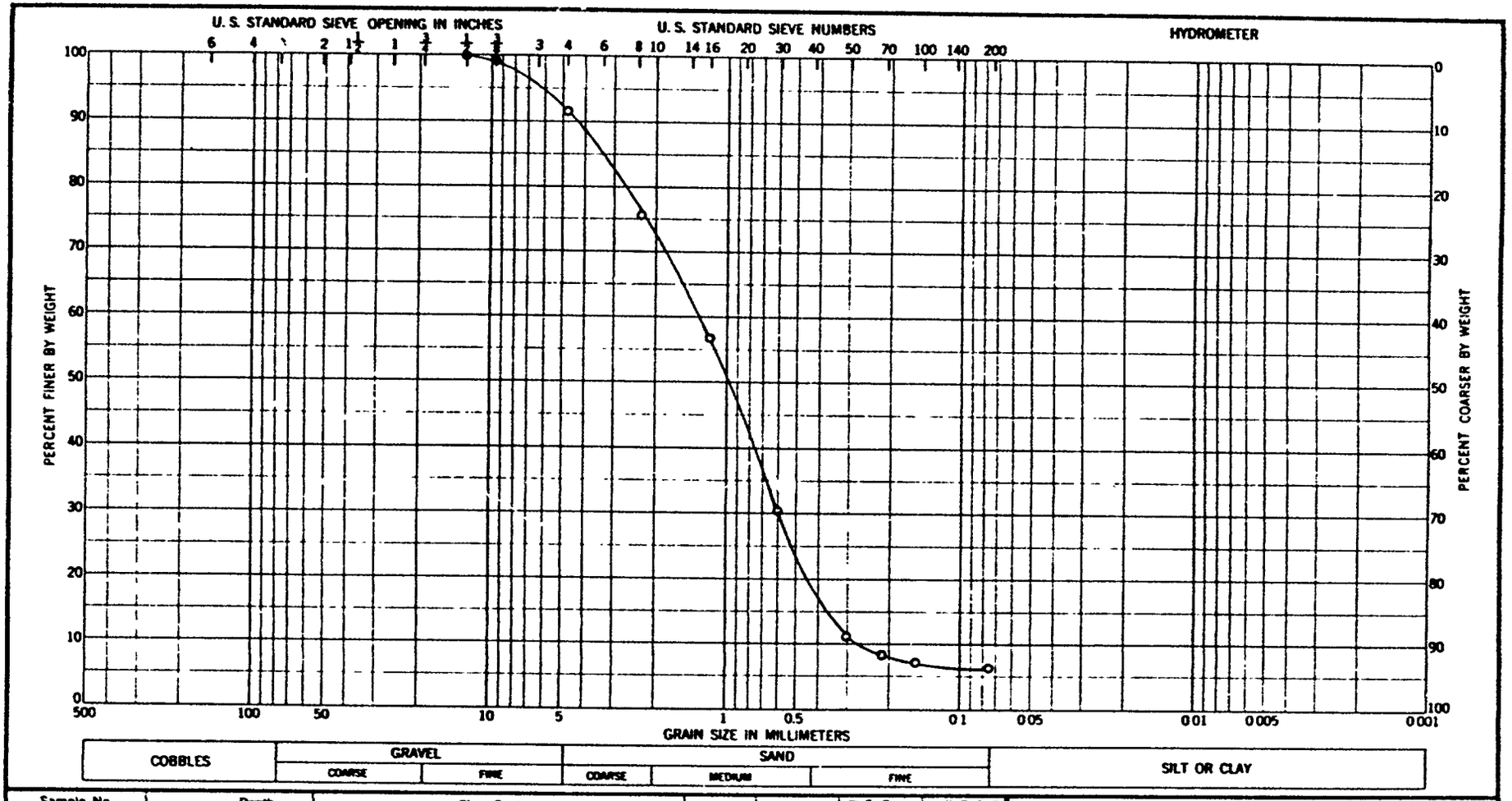
Sample No	Depth	Classification			D10	-#200
6	13.0-14.0	SP-SC Br. clayey coarse to sand, with gravel		fine	0.27	5.2%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-85
Date 12 October 1989

PLATE C-34

ENG FORM 1 MAY 63 2087

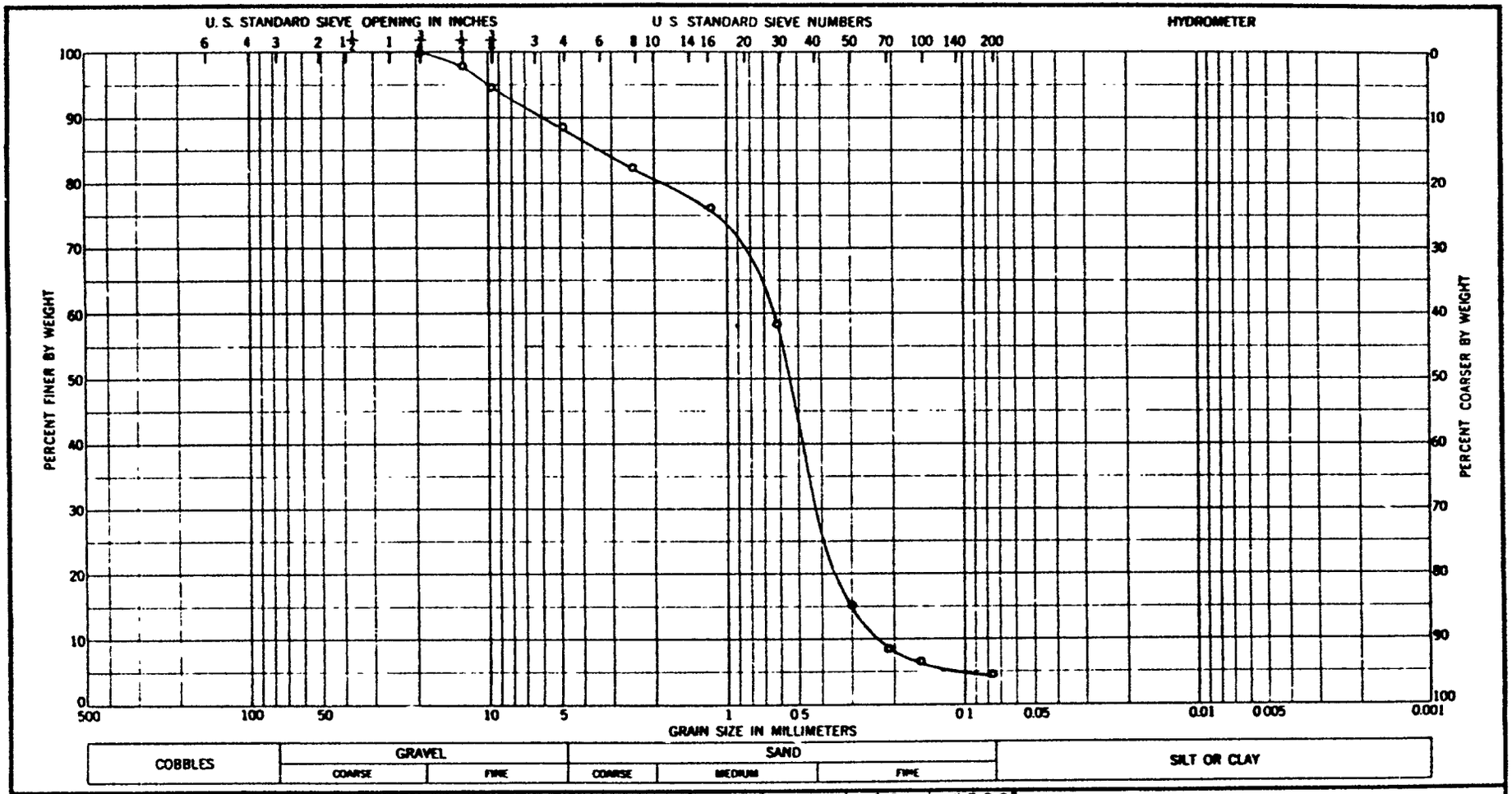


Sample No	Depth	Classification	D10	-#200
7	15.5-16.5	SP-SC Br. clayey coarse to fine sand, with gravel	0.28	6.2%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-85
Date 12 October 1989

PLATE C-35



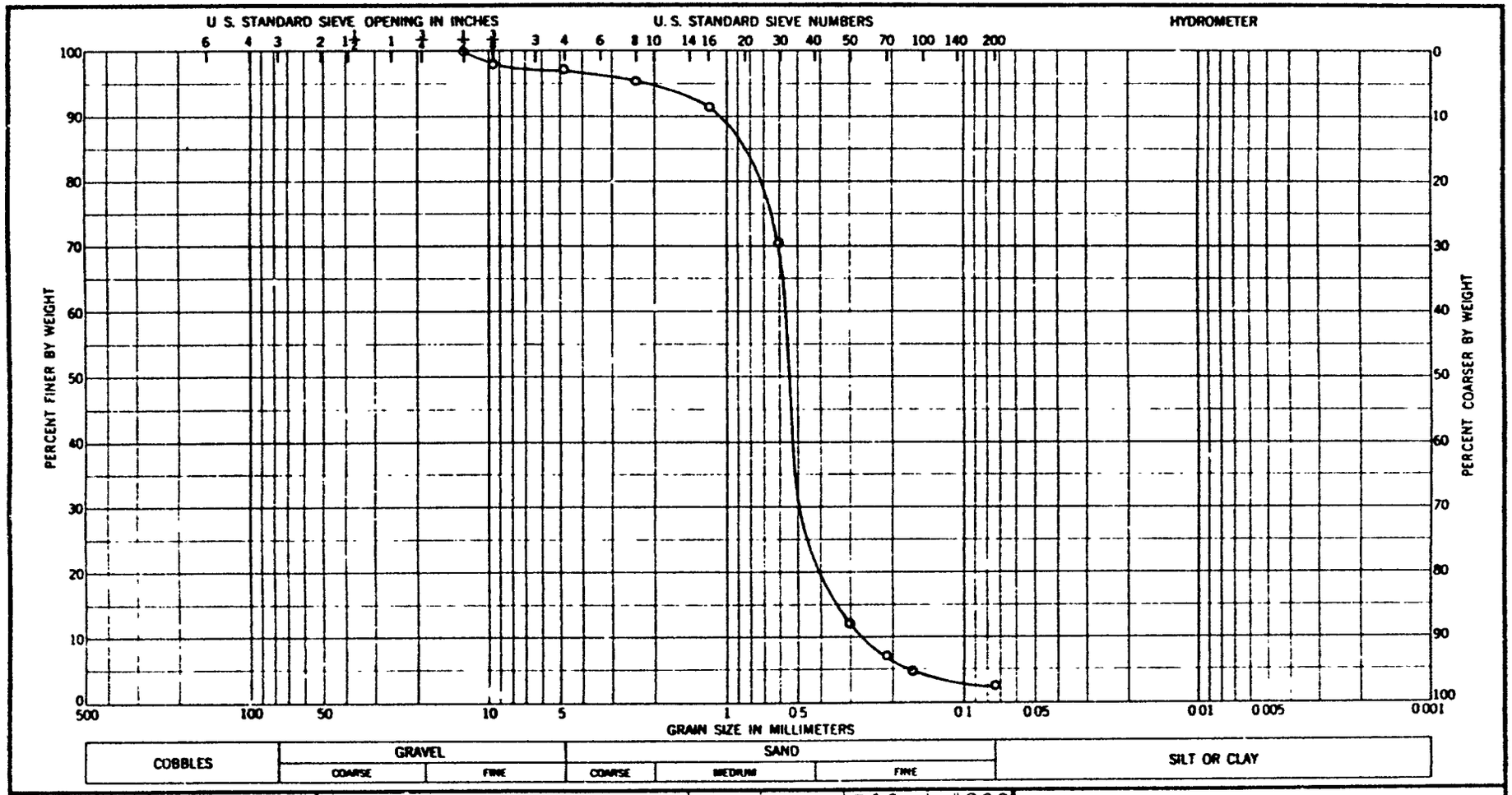
Sample No	Depth	Classification	D10	-#200
9	25.5-26.5	CP Br. gravelly medium to fine sand	0.24	4.5%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-85
Date 12 October 1989

PLATE C-36

ENG FORM 1 MAY 63 2087



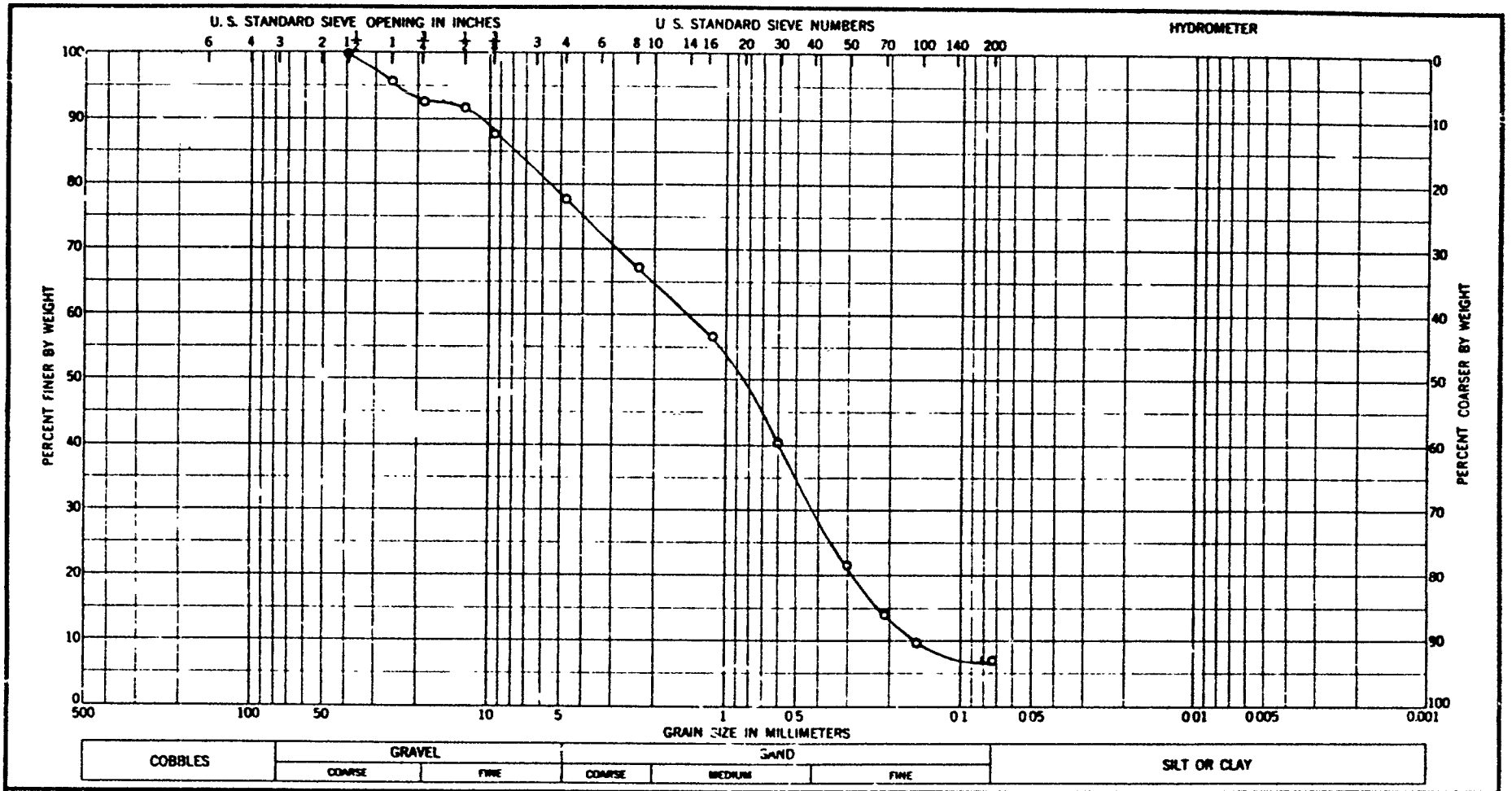
Sample No	Depth	Classification			D10	-#200
10	30.5-31.5	SP Gr. medium to fine	sand		0.27	3.4%

GRADATION CURVES

Project WEST DES MOINES
DES MOINES, IOWA
Area
Boring No. WDM-89-85
Date 12 October 1989

PLATE C-37

ENG FORM MAY 63 2087



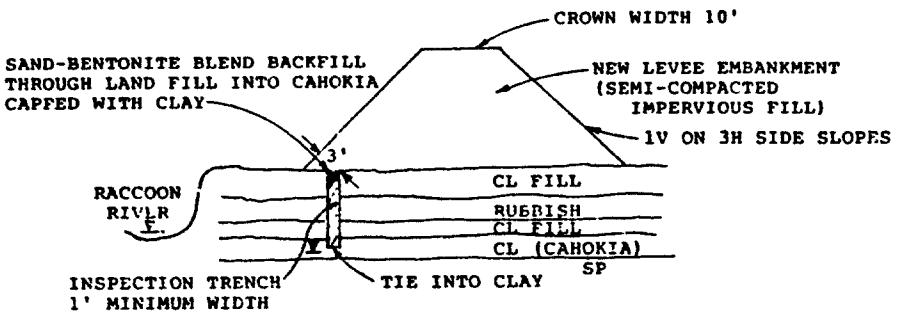
Sample No	Depth	Classification			D10	-#200
11	35.5-36.5	SP-SC Br. clayey gravelly coarse to fine sand			0.16	7.0%

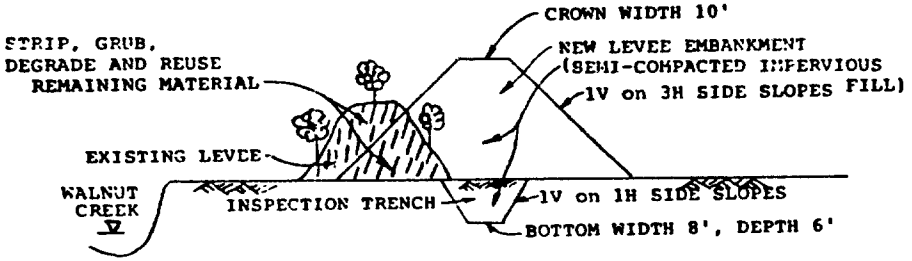
GRADATION CURVES

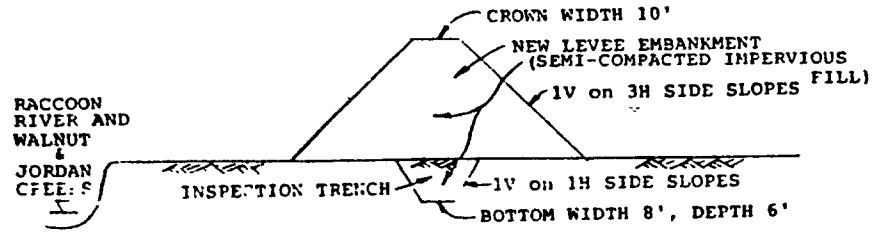
Project: WEST DES MOINES
DES MOINES, IOWA
Area:
Boring No.: WDM-89-85
Date: 12 October 1989

PLATE C-38

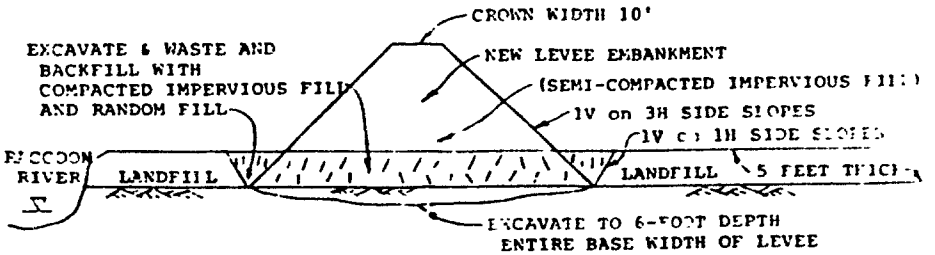
ENG FORM 1 MAY 63 2087

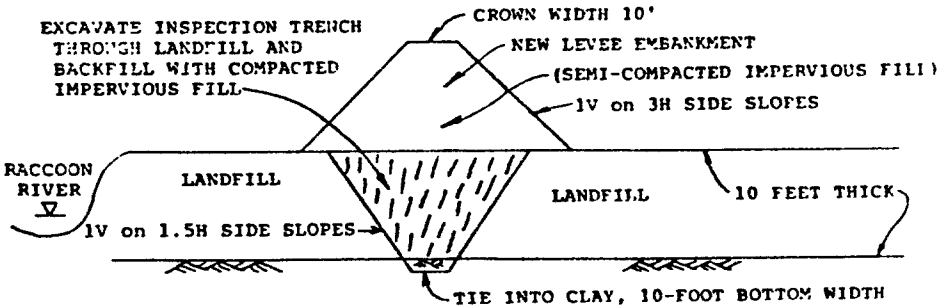


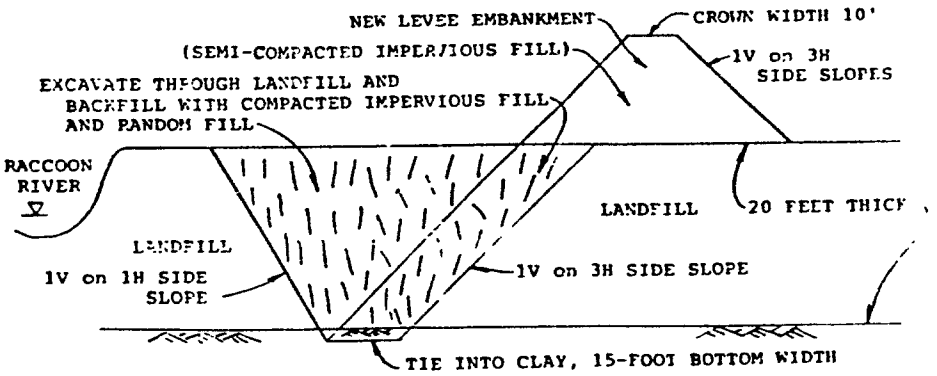




(DRAWINGS NOT TO SCALE)







(DRAWINGS NOT TO SCALE)

RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA
TYPICAL SECTIONS

PLATE C-39

WEST DES MOINES - DES MOINES, IOWA
59th Street and Valley Drive Borrow Site

HOLE	DEPTH	TOP ELEV.
WDM-89-61	0.0'-3.0'	807.4
WDM-89-62	0.0'-5.0'	805.5
WDM-89-63	0.0'-3.0'	808.1
WDM-89-64	0.0'-3.0'	807.8
WDM-89-65	0.0'-3.0'	807.7

Combined Borrow Sample - Group 1
% Retained on #4 sieve = 0
% Retained on #200 sieve = 8.7%
Classification
LL = 53 PL = 22 PI = 31
CL-CH Gray medium clay, trace roots
Standard Proctor Compaction Curve
Automatic (Rainhart) Hammer

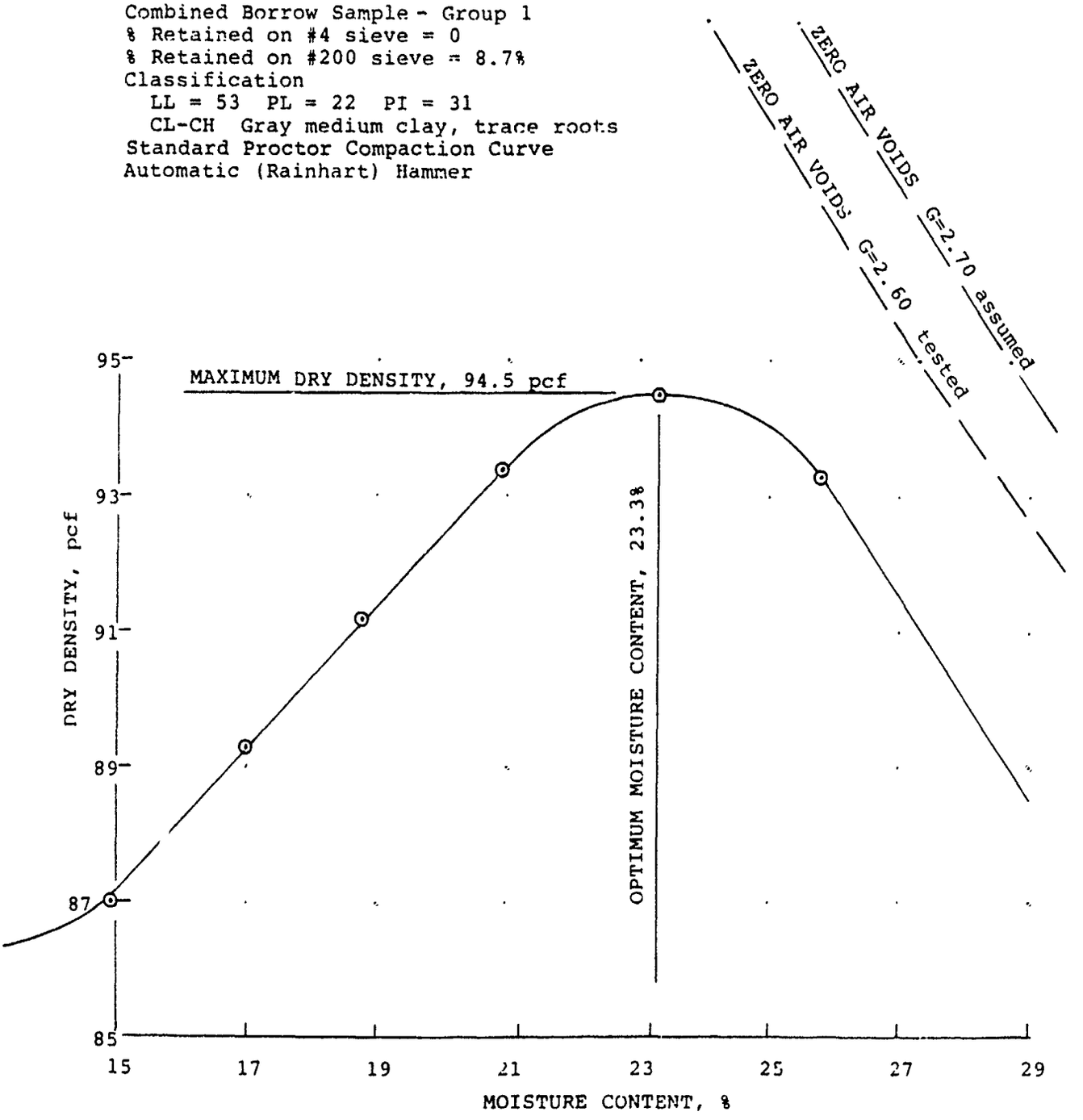


PLATE C-40

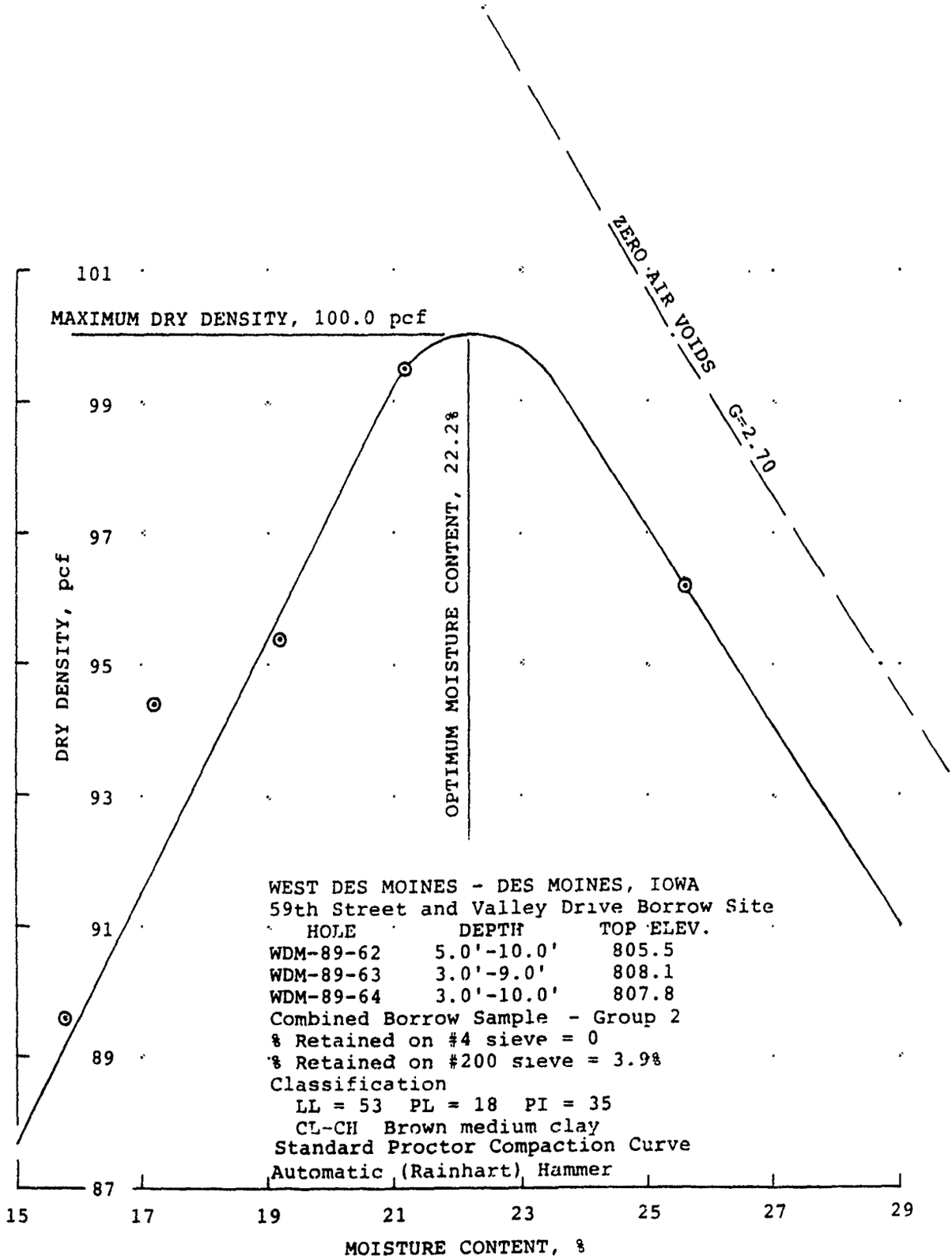

ZERO AIR VOIDS
G=2.70
101
99
97
95
93
91
89
87
MAXIMUM DRY DENSITY, 100.0 pcf
OPTIMUM MOISTURE CONTENT, 22.2%
DRY DENSITY, pcf
WEST DES MOINES - DES MOINES, IOWA
59th Street and Valley Drive Borrow Site
HOLE DEPTH TOP ELEV.
WDM-89-62 5.0'-10.0' 805.5
WDM-89-63 3.0'-9.0' 808.1
WDM-89-64 3.0'-10.0' 807.8
Combined Borrow Sample - Group 2
% Retained on #4 sieve = 0
% Retained on #200 sieve = 3.9%
Classification
LL = 53 PL = 18 PI = 35
CL-CH Brown medium clay
Standard Proctor Compaction Curve
Automatic (Rainhart) Hammer
15
17
19
21
23
25
27
29
MOISTURE CONTENT, %

PLATE C-41

WEST DES MOINES - DES MOINES, IOWA
Fuller Road Borrow Site

HOLE	DEPTH	TOP ELEV.
WDM-89-86	0.0'-5.0'	817.8
WDM-89-87	0.0'-5.0'	817.1
WDM-89-88	0.0'-5.0'	817.8

Combined Borrow Sample - Group 3
% Retained on #4 sieve = 0
% Retained on #200 sieve = 2.9%
Classification
LL = 57 PL = 19 PI = 38
CH Gray fat clay.
Standard Proctor Compaction Curve
Automatic (Rainhart) Hammer

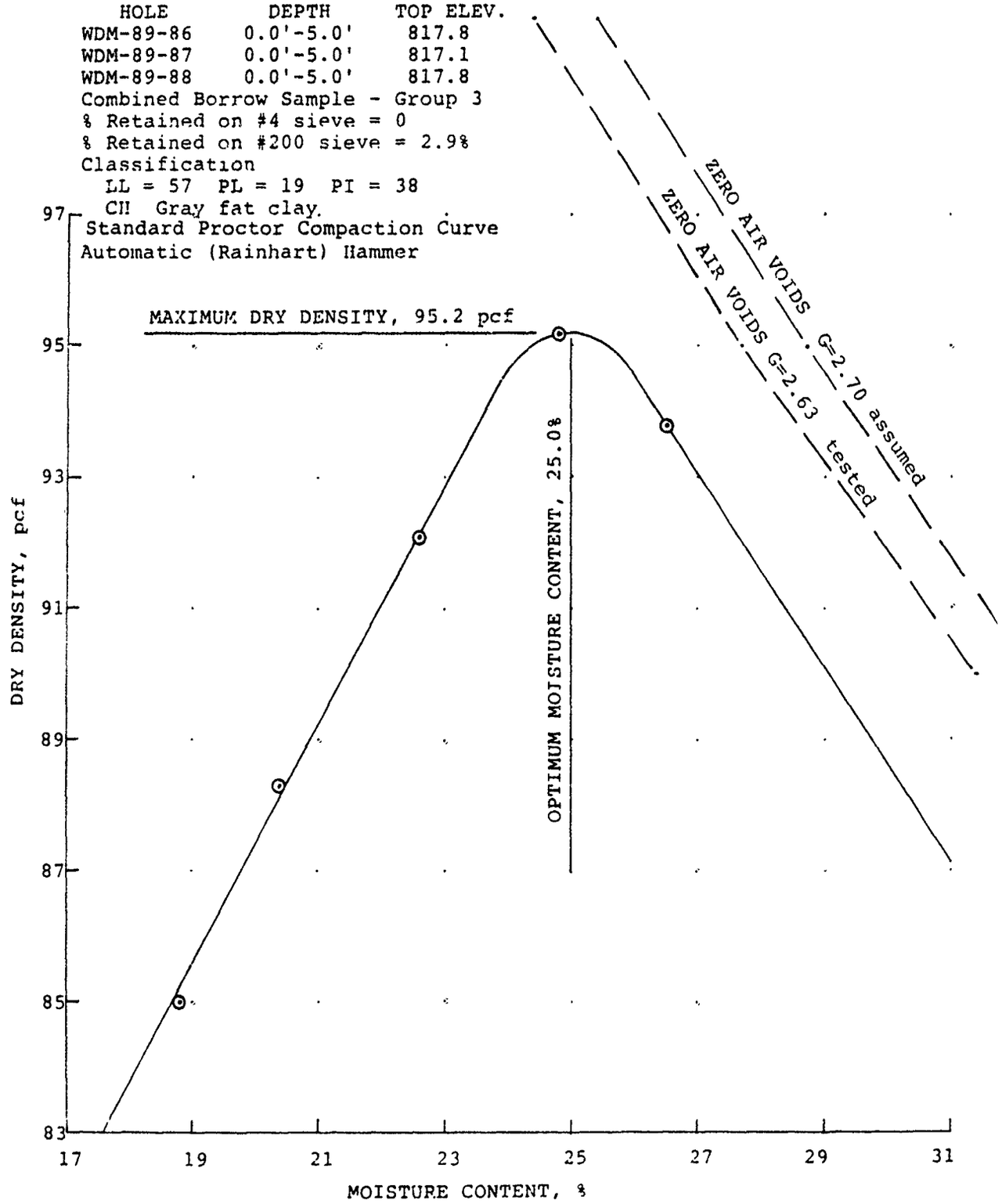


PLATE C-42

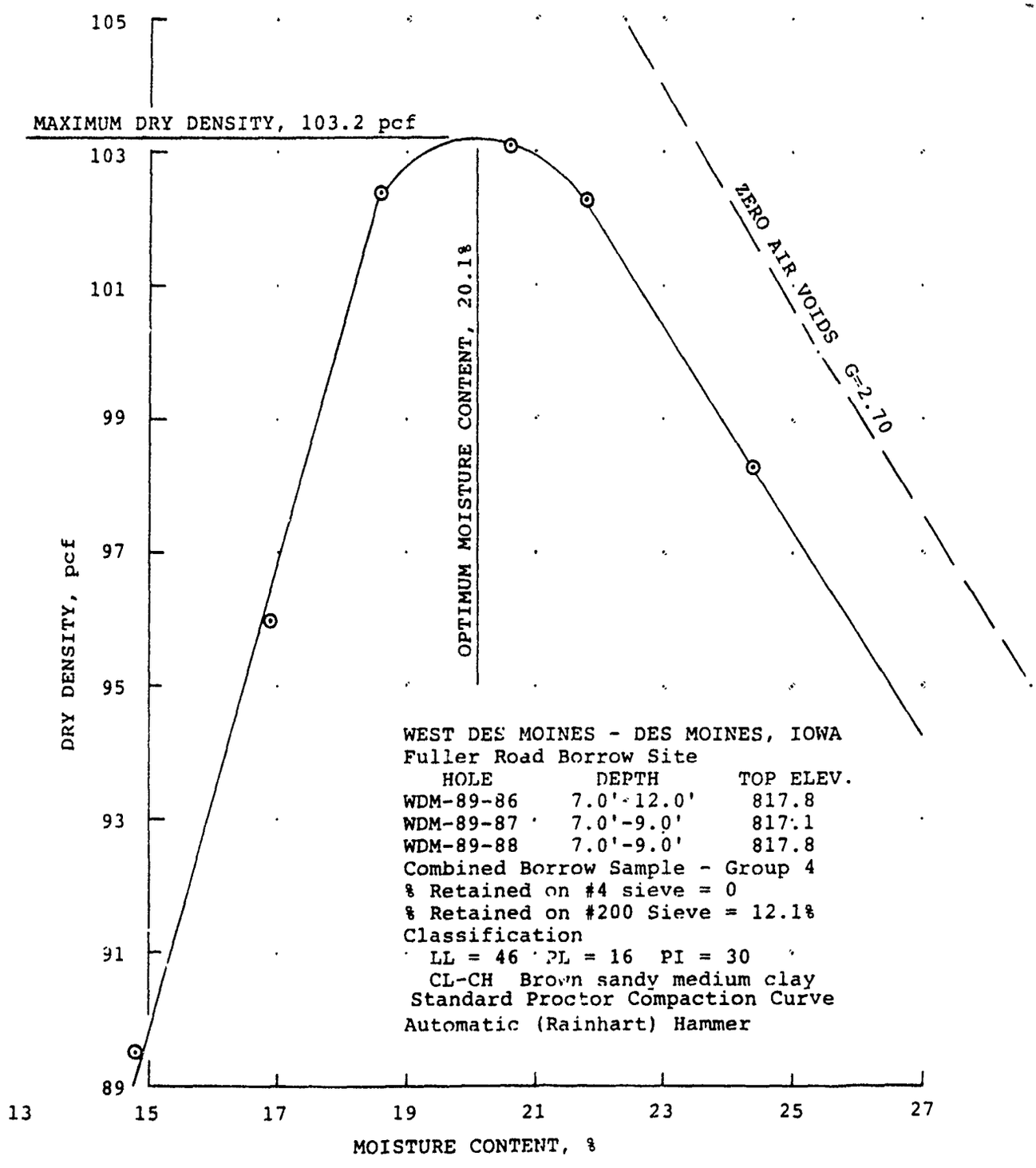

105
103
101
99
97
95
93
91
89
MAXIMUM DRY DENSITY, 103.2 pcf
OPTIMUM MOISTURE CONTENT, 20.1%
ZERO AIR VOIDS G=2.70
DRY DENSITY, pcf
13
15
17
19
21
23
25
27
MOISTURE CONTENT, %
WEST DES MOINES - DES MOINES, IOWA
Fuller Road Borrow Site
HOLE DEPTH TOP ELEV.
WDM-89-86 7.0'-12.0' 817.8
WDM-89-87 7.0'-9.0' 817.1
WDM-89-88 7.0'-9.0' 817.8
Combined Borrow Sample - Group 4
% Retained on #4 sieve = 0
% Retained on #200 Sieve = 12.1%
Classification
LL = 46 PL = 16 PI = 30
CL-CH Brown sandy medium clay
Standard Proctor Compaction Curve
Automatic (Rainhart) Hammer

PLATE C 43

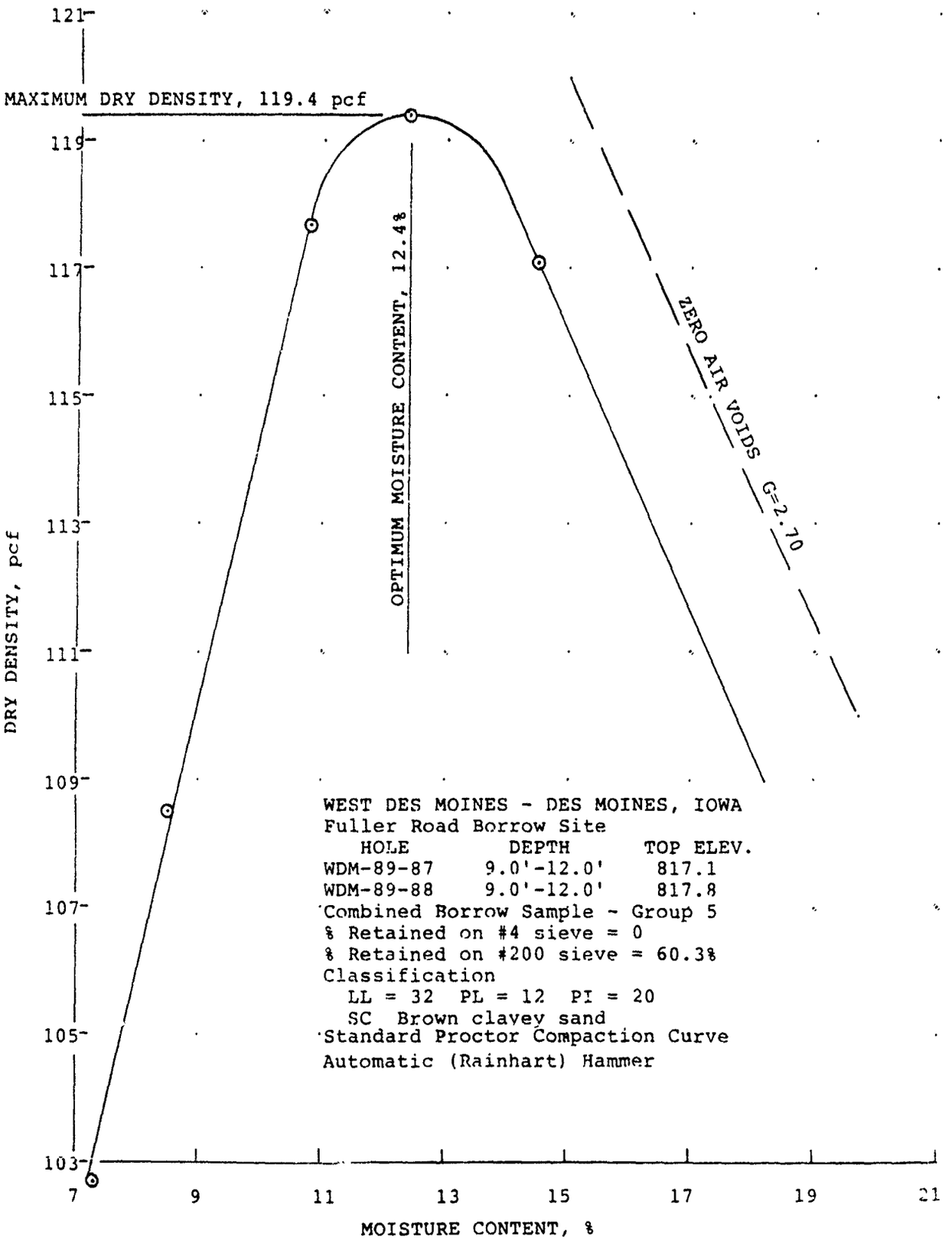

MAXIMUM DRY DENSITY, 119.4 pcf
OPTIMUM MOISTURE CONTENT, 12.4%
ZERO AIR VOIDS G=2.70
DRY DENSITY, pcf
MOISTURE CONTENT, %
121
119
117
115
113
111
109
107
105
103
7
9
11
13
15
17
19
21
WEST DES MOINES - DES MOINES, IOWA
Fuller Road Borrow Site
HOLE DEPTH TOP ELEV.
WDM-89-87 9.0'-12.0' 817.1
WDM-89-88 9.0'-12.0' 817.8
Combined Borrow Sample - Group 5
% Retained on #4 sieve = 0
% Retained on #200 sieve = 60.3%
Classification
LL = 32 PL = 12 PI = 20
SC Brown clayey sand
Standard Proctor Compaction Curve
Automatic (Rainhart) Hammer

PLATE C-44

WEST DES MOINES - DES MOINES, IOWA
PROPOSED BORROW SOURCES
MOISTURE CONTROL EVALUATION

GROUP CURVE NUMBER	DESIRED PERCENT OPTIMUM MOISTURE CONTROL LIMITS	ALLOWABLE RANGE OF MOISTURE CONTENTS %	OPTIMUM MOISTURE CONTENT %	ALLOWABLE DEVIATION FROM OPTIMUM MOISTURE CONTENT % (-)	ALLOWABLE DEVIATION FROM OPTIMUM MOISTURE CONTENT % (+)	SELECTED DEVIATION FROM OPTIMUM MOISTURE CONTENT % (-)	SELECTED DEVIATION FROM OPTIMUM MOISTURE CONTENT % (+)	RANGE OF NATURAL MOISTURE CONTENTS %	AVERAGE OF NATURAL MOISTURE CONTENTS %	DEVIATION OF AVERAGE NATURAL MOISTURE CONTENT FROM OPTIMUM MOISTURE CONTENT %	MAXIMUM DRY DENSITY p.c.f.	TYPE OF MIXED SOILS FROM SACK SAMPLE	BORROW SITE
1	90-120	21.0-28.0	23.3	2.3	4.7	2	4.5	18-26	22.7	-0.6	94.5	53/22 Gray CL-CH	59th St Valley Drive
2	90-120	20.0-26.6	22.2	2.2	4.4	2	4.5	19-29	25.5	+3.3	100.0	53/18 Brown CL-CH	59th St Valley Drive
3	90-120	22.5-30.0	25.0	2.5	5.0	2.5	5	24-28	26.7	+1.7	95.2	57/19 Gray CH	Fuller Road
4	90-120	18.1-24.1	20.1	2.0	4.0	2	4	24-25	24.5	+4.4	103.2	46/16 Brown Sandy CL-CH	Fuller Road
5	90-120	11.2-14.9	12.4	1.2	2.5	1	2.5	16-18	17.0	+4.6	119.4	32/12 Brown SC	Fuller Road

PLATE C-45

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		SOILS STRATUM THICKNESS IN FEET				ELEVATION
DESIGNATD	SPECIFIED	LAND FILL	CAHOKIA CL,CL-CH, CH/ TOP STRATUM	HENRY SP-SC SUB-STRATUM	HENRY SP SUB-STRATUM	PENN. SHALE BEDROCK
-----	WDM-65-1	-----	7	3	-----	-----
-----	WDM-65-2	2	13	1	-----	-----
-----	WDM-65-3	6	4	5	-----	-----
-----	WDM-65-4	-----	11	1	-----	-----
-----	WDM-65-5	-----	5	1	5	-----
-----	WDM-65-6	-----	9	-----	5	-----
-----	WDM-65-7	3	5	-----	-----	-----
-----	WDM-65-8	-----	9	1	5	-----
-----	WDM-65-9	-----	10	-----	-----	-----
-----	WDM-65-10	-----	11	5	-----	-----
-----	WDM-65-11	-----	12	1	-----	-----
-----	WDM-65-12	-----	10	-----	-----	-----
-----	WDM-65-13	-----	10	1	5	-----
-----	WDM-65-14	-----	16	-----	4	-----
-----	WDM-65-15	-----	10	-----	-----	-----
-----	WDM-65-16	-----	17	-----	1	-----
-----	WDM-65-17	-----	13	1	-----	-----
-----	WDM-65-18	-----	8	-----	-----	-----
-----	WDM-65-19	-----	17	-----	1	-----
-----	WDM-65-20	-----	14	-----	3	-----
-----	WDM-65-21	-----	10	-----	-----	-----
-----	WDM-65-22	-----	12	-----	3	-----

(CONTINUED)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		SOILS STRATUM THICKNESS IN FEET				ELEVATION
DESIGNATD	SPECIFIED	LAND FILL	CAHOKIA CL,CL-CH, CH/ TOP STRATUM	HENRY SP-SC SUB-STRATUM	HENRY SP SUB-STRATUM	PENN. SHALE BEDROCK
-----	WDM-65-23	-----	7/8	-----	3	-----
-----	WDM-65-24	-----	10	-----	-----	-----
-----	WDM-65-25	-----	7	-----	3	-----
-----	WDM-65-26	-----	5	2	4	-----
-----	WDM-65-27	-----	10	-----	-----	-----
-----	WDM-65-28	-----	9	-----	5	-----
-----	WDM-65-29	1	11	-----	-----	-----
-----	WDM-65-30	-----	4	-----	8	-----
-----	WDM-65-31	-----	4	-----	1	-----
-----	WDM-65-32	1	7/10	3	-----	-----
-----	WDM-65-33	1	14	-----	6	-----
-----	WDM-65-34	-----	16	-----	-----	-----
-----	WDM-65-35	-----	8/9	1	3	-----
-----	WDM-65-36	-----	6	-----	-----	-----
-----	WDM-65-37	-----	8	-----	6	-----
-----	WDM-65-38	-----	7	-----	3	-----
-----	WDM-65-39	-----	8	-----	-----	-----
-----	WDM-65-40	-----	13	-----	1	-----
-----	WDM-65-41	-----	7	-----	6	-----
-----	WDM-65-42	-----	12	-----	3	-----
-----	WDM-65-43	4	-----	-----	-----	-----
-----	WDM-65-44	6	10	-----	-----	-----

(CONTINUED)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		SOILS STRATUM THICKNESS IN FEET				ELEVATION
DESIGNATD	SPECIFIED	LAND FILL	CAHOKIA CL,CL-CH, CH/ TOP STRATUM	HENRY SP-SC SUB-STRATUM	HENRY SP SUB-STRATUM	PENN. SHALE BEDROCK
-----	WDM-65-45	-----	14	-----	4	-----
-----	WDM-65-46	-----	12/13	-----	5	-----
-----	WDM-65-47	1	15/16	3	2	-----
-----	WDM-65-48	-----	16	-----	-----	-----
-----	WDM-65-49	2	8	-----	-----	-----
-----	WDM-65-50	-----	12	-----	-----	-----
-----	WDM-65-51	-----	9	5	-----	-----
-----	WDM-65-52	1	11	-----	-----	-----
BLUE 1	WDM-89-53	-----	14	-----	5	-----
RED 2	WDM-89-54	1/2	18/20	-----	23	776-770
RED 3	WDM-89-55	1/2	21/23	10	10	775-772
BLUE 4A	WDM-89-56	2 CL	5	-----	10	-----
BLUE 4B	WDM-89-57	11 CL	12/16	-----	-----	-----
RED 6	WDM-89-58	7 CL	5	21	5	773-771
RED 5A	WDM-89-59	-----	11	3	10	773-770
RED 12	WDM-89-60	-----	19	4	4	-----
RED 14	WDM-89-61	-----	3	-----	12	-----
RED 13	WDM-89-62	-----	13	-----	2	-----
RED 15	WDM-89-63	-----	15	-----	-----	-----
RED 16	WDM-89-64	-----	13	2	-----	-----
RED 17	WDM-89-65	-----	14	-----	1	-----
BLUE 7	WDM-89-66	10 CL	14	-----	8	-----

(CONTINUED)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		SOILS STRATUM THICKNESS IN FEET				ELEVATION
DESIGNATD	SPECIFIED	LAND FILL	CAHOKIA CL,CL-CH, CH/ TOP STRATUM	HENRY SP-SC SUB-STRATUM	HENRY SP SUB-STRATUM	PENN. SHALE BEDROCK
BLUE 5	WDM-89-67	-----	9	17	7	766-764
RED 20	WDM-89-68	15 CL	7	5	-----	-----
RED 21	WDM-89-69	18 CL	3	1	-----	-----
RED 18	WDM-89-70	2 CL	12	20	4	770-766
RED 22A	WDM-89-71	20 CW	-----	-----	5	-----
RED 22	WDM-89-72	-----	14	5	30	759-757
BLUE 15	WDM-89-73	-----	12	-----	4	-----
RED 23	WDM-89-74	10 CW	5/7	-----	4	-----
RED 24	WDM-89-75	13 CL	3	-----	5	-----
RED 25	WDM-89-76	4 CL, 9 D	-----	-----	8	-----
RED 26	WDM-89-77	13 CL	2/4	-----	4	-----
RED 28	WDM-89-78	-----	11	-----	10	-----
RED 29	WDM-89-79	12 CL	10	-----	2	792-790
RED 30	WDM-89-80	12 SC	10	-----	2	792
RED 31	WDM-89-81	7 SP	14	-----	-----	793
RED 32	WDM-89-82	3 SC	8	5	-----	-----
RED 33	WDM-89-83	1 CS	8	-----	7	-----
RED 34	WDM-89-84	-----	9/12	-----	5	-----
RED 35	WDM-89-85	-----	10	22	8	775-774
RED 37	WDM-89-86	-----	14	-----	1	-----
RED 38	WDM-89-87	-----	12	3	-----	-----
RED 39	WDM-89-88	-----	12	3	-----	-----
RANGE		(1/2-20)	(3-23)	(1-22)	(1-30)	(793-759)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		RNG OF MOISTURE CONTENT PERCENT OF DRY WEIGHT CAHOKIA SOILS			RNG OF COHESIVE SHEAR STRENGTH POUNDS PER SQUARE FOOT CAHOKIA SOILS		
DESIGNTD	SPECIFIED	CL	CL-CH	CH	CL	CL-CH	CH
------	WDM-65-1	16-22	-----	-----	560-780	-------	-------
------	WDM-65-2	24-25	32	26-39	500-520	550	530-1000+
------	WDM-65-3	26-29	-----	-----	430-480	------	-------
------	WDM-65-4	25-30	-----	-----	420-500	------	-------
------	WDM-65-5	24-38	-----	-----	310-520	------	-------
------	WDM-65-6	25-30	-----	-----	420-500	------	-------
------	WDM-65-7	27-29	-----	-----	430-470	------	-------
------	WDM-65-8	23-25	-----	-----	500-540	------	-------
------	WDM-65-9	12-25	-----	-----	500-1000+	------	-------
------	WDM-65-10	23-30	-----	-----	420-540	------	-------
------	WDM-65-11	24-27	35	-----	470-520	440	-------
------	WDM-65-12	13-27	-----	-----	470-1000+	------	-------
------	WDM-65-13	22-40	-----	-----	280-560	------	-------
-----	WDM-65-14	26-35	-----	25-31	350-480	------	740-1000+
------	WDM-65-15	10-18	-----	23	700-1000+	------	1000+
------	WDM-65-16	23	33	30-36	540	500	580-1000
------	WDM-65-17	38	27-36	26	310	410-1000+	1000+
------	WDM-65-18	------	21-25	24	-----	1000+	1000+
------	WDM-65-19	32-35	35-46	47	350-390	230-440	450
------	WDM-65-20	25-36	43	-----	340-500	270	-------
------	WDM-65-21	18-28	-----	24	450-700	------	1000+
------	WDM-65-22	29-33	45	-----	370-430	240	-------

(CONTINUED)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		RNG OF MOISTURE CONTENT PERCENT OF DRY WEIGHT CAHOKIA SOILS			RNG OF COHESIVE SHEAR STRENGTH POUNDS PER SQUARE FOOT CAHOKIA SOILS		
DESIGNTD	SPECIFIED	CL	CL-CH	CH	CL	CL-CH	CH
------	WDM-65-23	25	-----	38-52	500	------	420-540
------	WDM-65-24	11	22	26-39	1000+	1000+	530-1000+
------	WDM-65-25	------	39-43	59	-------	270-330	380
------	WDM-65-26	37	-----	41	330	------	500
------	WDM-65-27	21-33	-----	24	370-590	------	1000+
------	WDM-65-28	27-37	42	-----	330-470	290	-------
------	WDM-65-29	26-36	-----	-----	340-480	------	-------
------	WDM-65-30	32	-----	-----	390	------	-------
------	WDM-65-31	30	-----	-----	420	------	-------
------	WDM-65-32	------	27-34	-----	-------	470-1000+	-------
------	WDM-65-33	22-33	41	-----	370-560	300	-------
------	WDM-65-34	20-34	32-34	-----	360-620	470-550	-------
------	WDM-65-35	22-31	-----	-----	400-560	------	-------
------	WDM-65-36	26	-----	-----	480	------	-------
------	WDM-65-37	31-33	35	-----	370-400	440	-------
------	WDM-65-38	22-35	-----	-----	350-560	------	-------
------	WDM-65-39	20-26	-----	-----	480-620	------	-------
------	WDM-65-40	29-32	29-43	-----	390-430	270-780	-------
------	WDM-65-41	------	-----	41-45	-------	------	470-500
------	WDM-65-42	29-39	-----	38-45	290-430	------	470-540
------	WDM-65-43	------	-----	-----	-------	------	-------
------	WDM-65-44	------	-----	28-36	-------	------	580-1000+

(CONTINUED)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		RNG OF MOISTURE CONTENT PERCENT OF DRY WEIGHT CAHOKIA SOILS			RNG OF COHESIVE SHEAR STRENGTH POUNDS PER SQUARE FOOT CAHOKIA SOILS		
DESIGNTD	SPECIFIED	CL	CL-CH	CH	CL	CL-CH	CH
------	WDM-65-45	29-31	30-31	35-43	400-430	610-700	480-590
------	WDM-65-46	25-26	-----	25-30	480-500	------	1000+
------	WDM-65-47	17-27	18-29	28-31	470-750	780-1000+	740-1000+
------	WDM-65-48	27-35	24-35	23-24	350-470	440-1000+	1000+
------	WDM-65-49	13-21	-----	20	590-1000+	------	-------
------	WDM-65-50	26-35	-----	26-31	350-480	------	-------
------	WDM-65-51	25	-----	18-28	500	------	-------
------	WDM-65-52	------	22	24-41	-------	1000+	500-1000+
BLUE 1	WDM-89-53	19-28	-----	-----	450-660	------	-------
RED 2	WDM-89-54	18-27	24	-----	470-700	1000+	-------
RED 3	WDM-89-55	24-36	25	-----	340-520	1000+	-------
BLUE 4A	WDM-89-56	18-27	-----	-----	470-700	------	-------
BLUE 4B	WDM-89-57	18-27	-----	-----	470-700	------	-------
RED 6	WDM-89-58	30-34	-----	-----	360-420	------	-------
RED 5A	WDM-89-59	13,22-27	-----	-----	470-560	------	-------
RED 12	WDM-89-60	17-30	-----	-----	420-750	------	-------
RED 14	WDM-89-61	------	18	-----	-------	1000+	-------
RED 13	WDM-89-62	------	22-29	23-26	-------	780-1000+	1000+
RED 15	WDM-89-63	17-22	23-26	-----	560-750	1000+	-------
RED 16	WDM-89-64	23	24-29	-----	540	780-1000+	-------
RED 17	WDM-89-65	12,17-19	23-25	-----	660-750	1000+	-------
BLUE 7	WDM-89-66	22-30	-----	-----	420-560	------	-------

(CONTINUED)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		RNG OF MOISTURE CONTENT PERCENT OF DRY WEIGHT CAHOKIA SOILS			RNG OF COHESIVE SHEAR STRENGTH POUNDS PER SQUARE FOOT CAHOKIA SOILS		
DESIGNTD	SPECIFIED	CL	CL-CH	CH	CL	CL-CH	CH
BLUE 5	WDM-89-67	18-22	27-29	-----	560-700	780-1000+	-------
RED 20	WDM-89-68	22-26	27	-----	480-560	1000+	-------
RED 21	WDM-89-69	------	-----	-----	-------	------	-------
RED 18	WDM-89-70	23-26	23	-----	480-540	1000+	-------
RED 22A	WDM-89-71	------	-----	-----	-------	------	-------
RED 22	WDM-89-72	26-31	-----	-----	400-480	------	-------
BLUE 15	WDM-89-73	17-25	27-30	-----	500-750	700-1000+	-------
RED 23	WDM-89-74	31	-----	-----	400	------	-------
RED 24	WDM-89-75	33-37	-----	-----	330-370	------	-------
RED 25	WDM-89-76	------	-----	-----	-------	------	-------
RED 26	WDM-89-77	33	-----	-----	370	------	-------
RED 28	WDM-89-78	24-26	25	24-26	480-520	1000+	1000+
RED 29	WDM-89-79	22	-----	44-53	560	------	410-470
RED 30	WDM-89-80	------	-----	47-53	-------	------	410-450
RED 31	WDM-89-81	30-35	-----	32-47	350-420	------	450-680
RED 32	WDM-89-82	22-27	24	-----	470-560	1000+	-------
RED 33	WDM-89-83	24	26-28	-----	520	1000-1000+	-------
RED 34	WDM-89-84	25	20-28	-----	500	1000-1000+	-------
RED 35	WDM-89-85	19-23	24	-----	540-660	1000+	-------
RED 37	WDM-89-86	31	25	28	400	1000+	1000+
RED 38	WDM-89-87	------	24	28	-------	1000+	1000+
RED 39	WDM-89-88	------	24	24	-------	1000+	1000+
RANGE		(10-40)	(18-46)	(18-59)	(280-750)	(230-780)	(380-740)

PLATE C-47C

WALNUT CREEK

STANDARD PROJECT FLOOD

WEST DES MOINES, IOWA

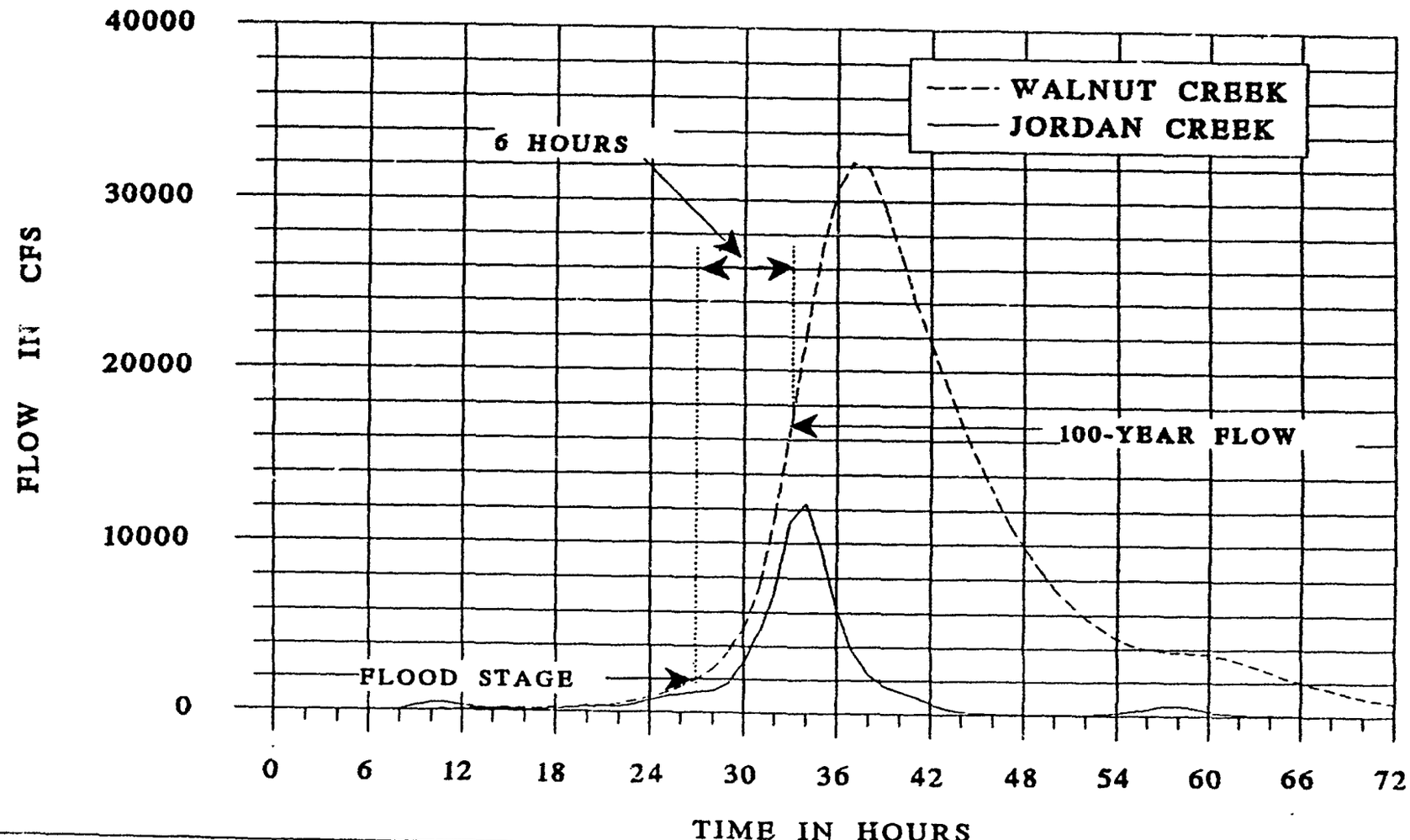


PLATE A-12

RACCOON RIVER

EXISTING CONDITION PROFILES

WEST DES MOINES, IOWA

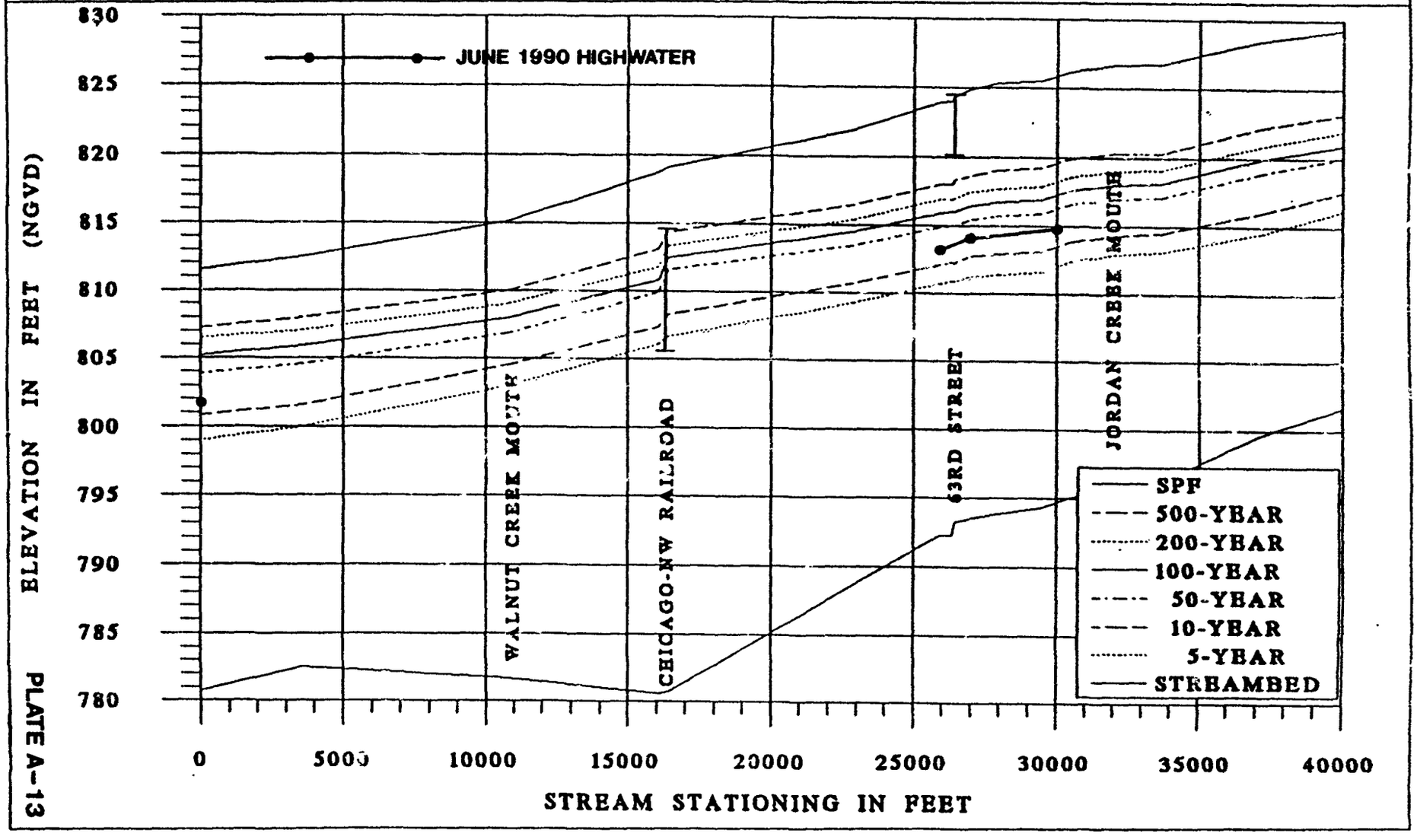


PLATE A-13

RACCOON RIVER

PROJECT CONDITION PROFILES

WEST DES MOINES, IOWA

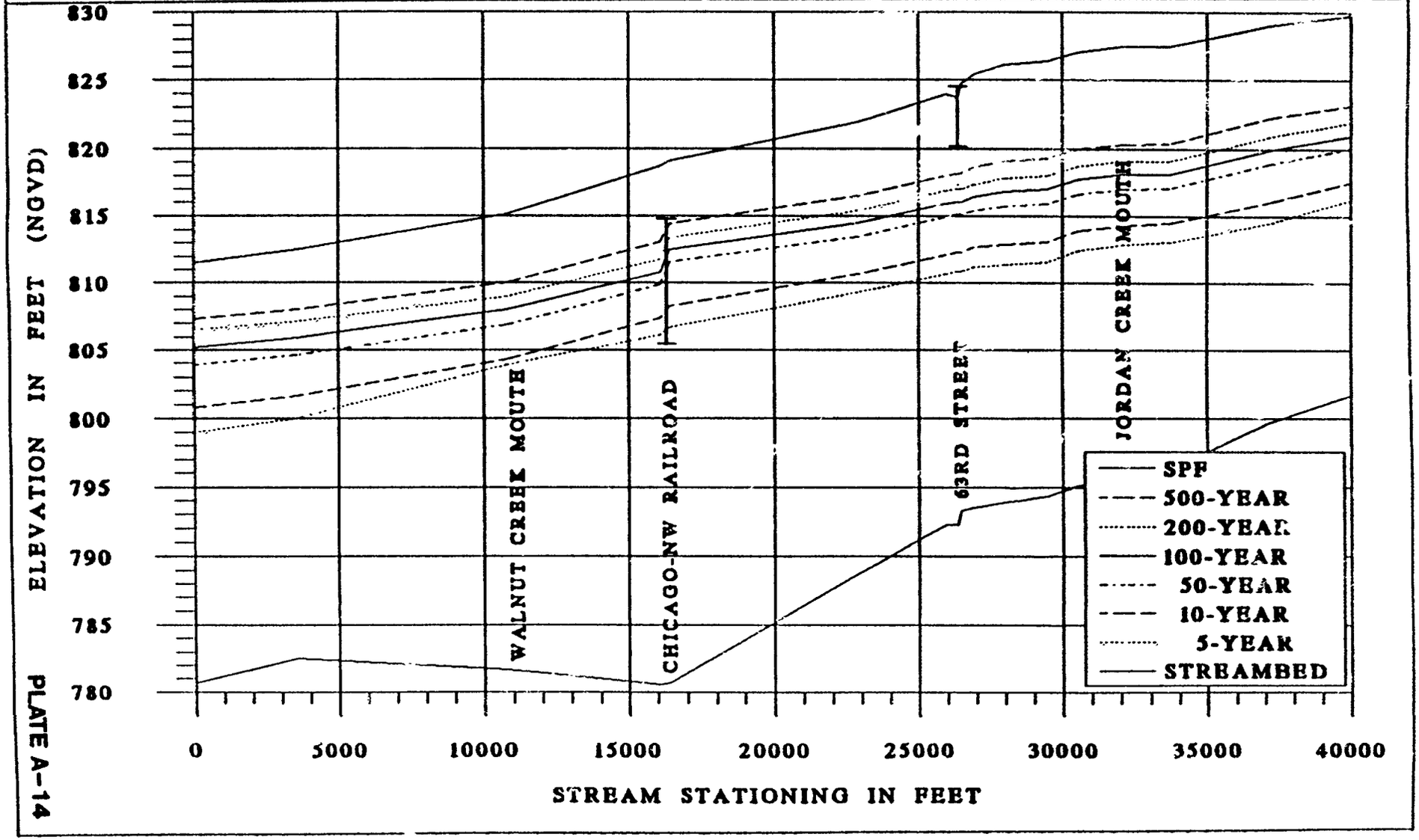


PLATE A-14

WALNUT CREEK

EXISTING CONDITION PROFILES

WEST DES MOINES, IOWA

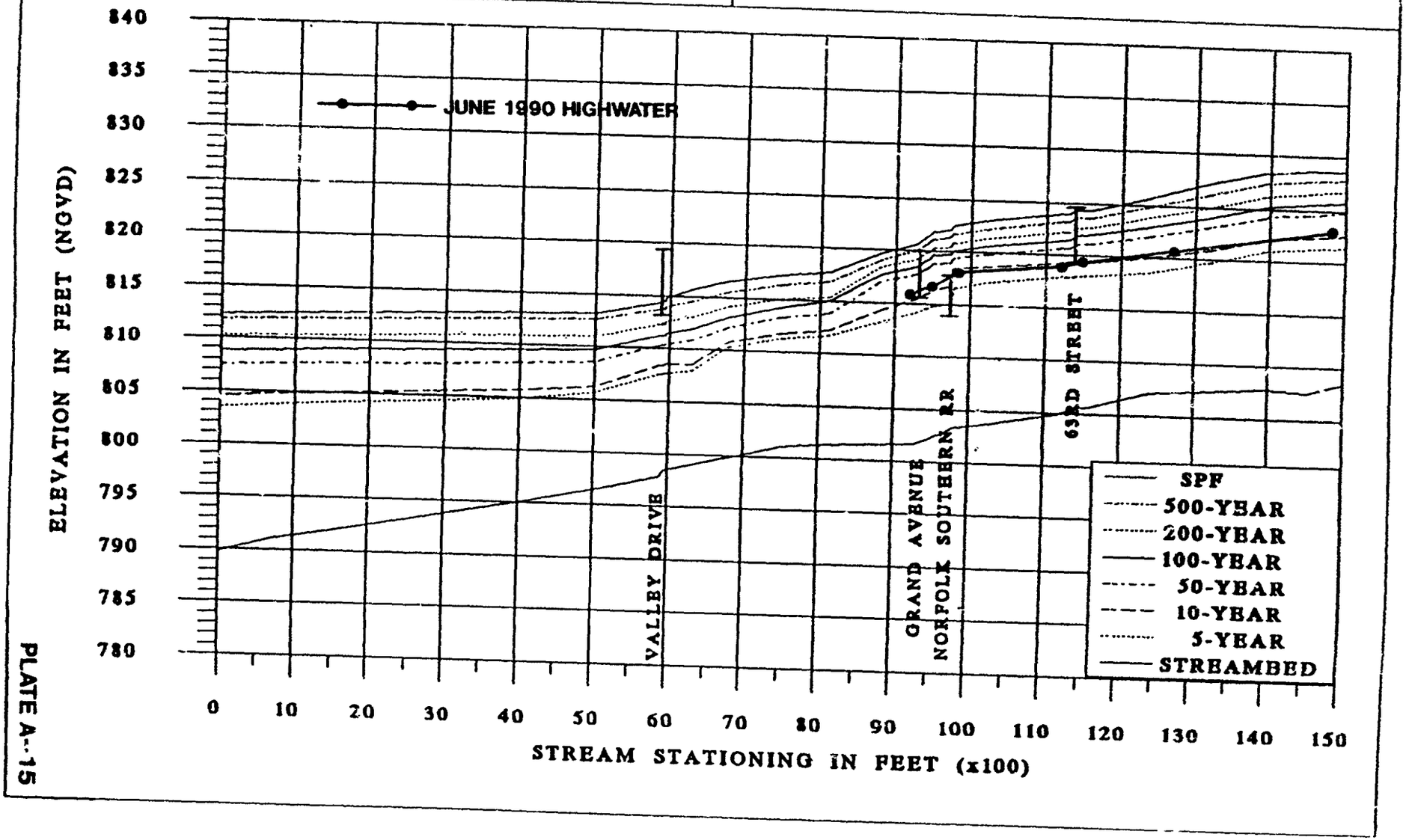


PLATE A-15

WALNUT CREEK

PROJECT CONDITION PROFILES

WEST DES MOINES, IOWA

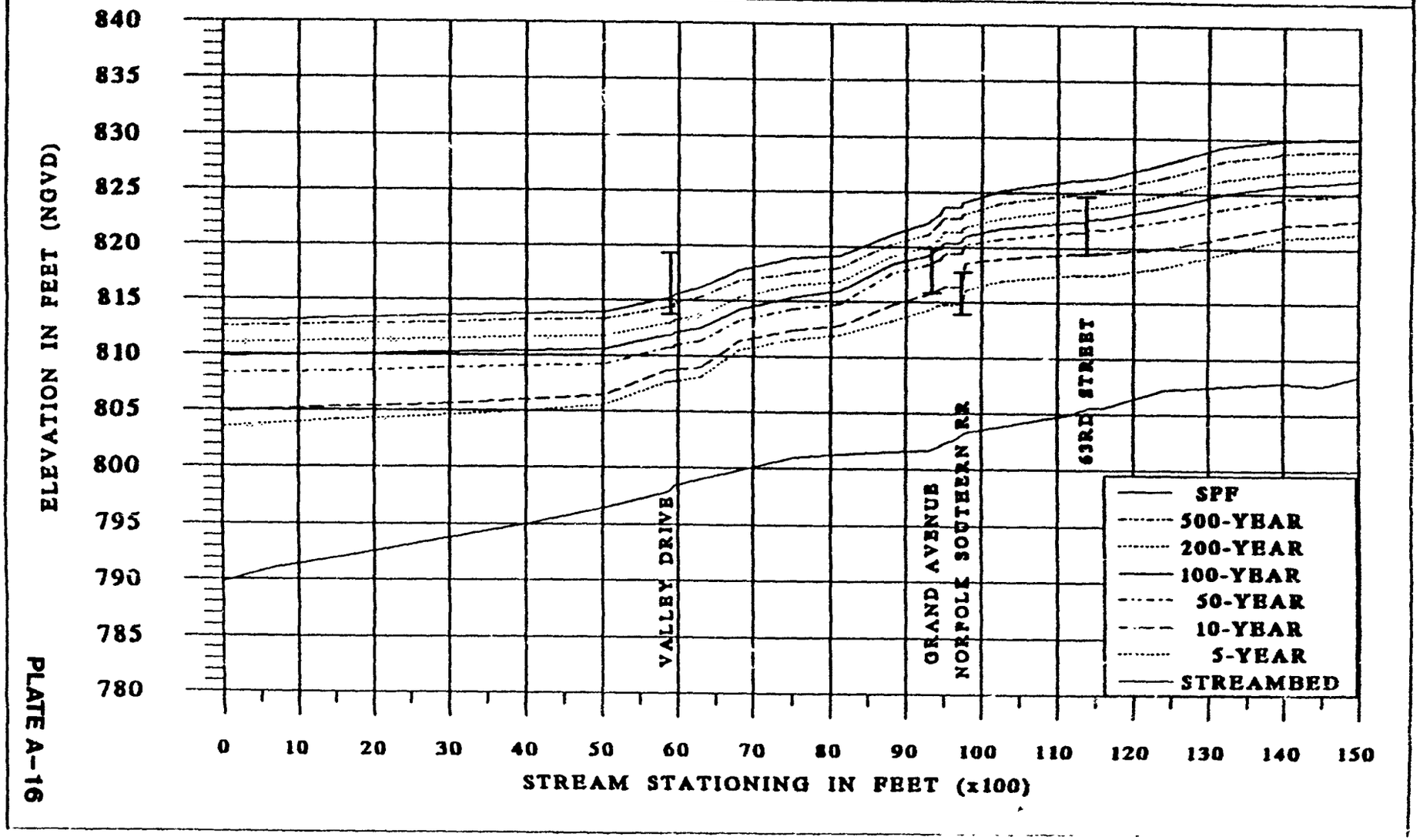


PLATE A-16

JUNE 1990 FLOODS

STAGE HYDROGRAPHS

WEST DES MOINES, IOWA

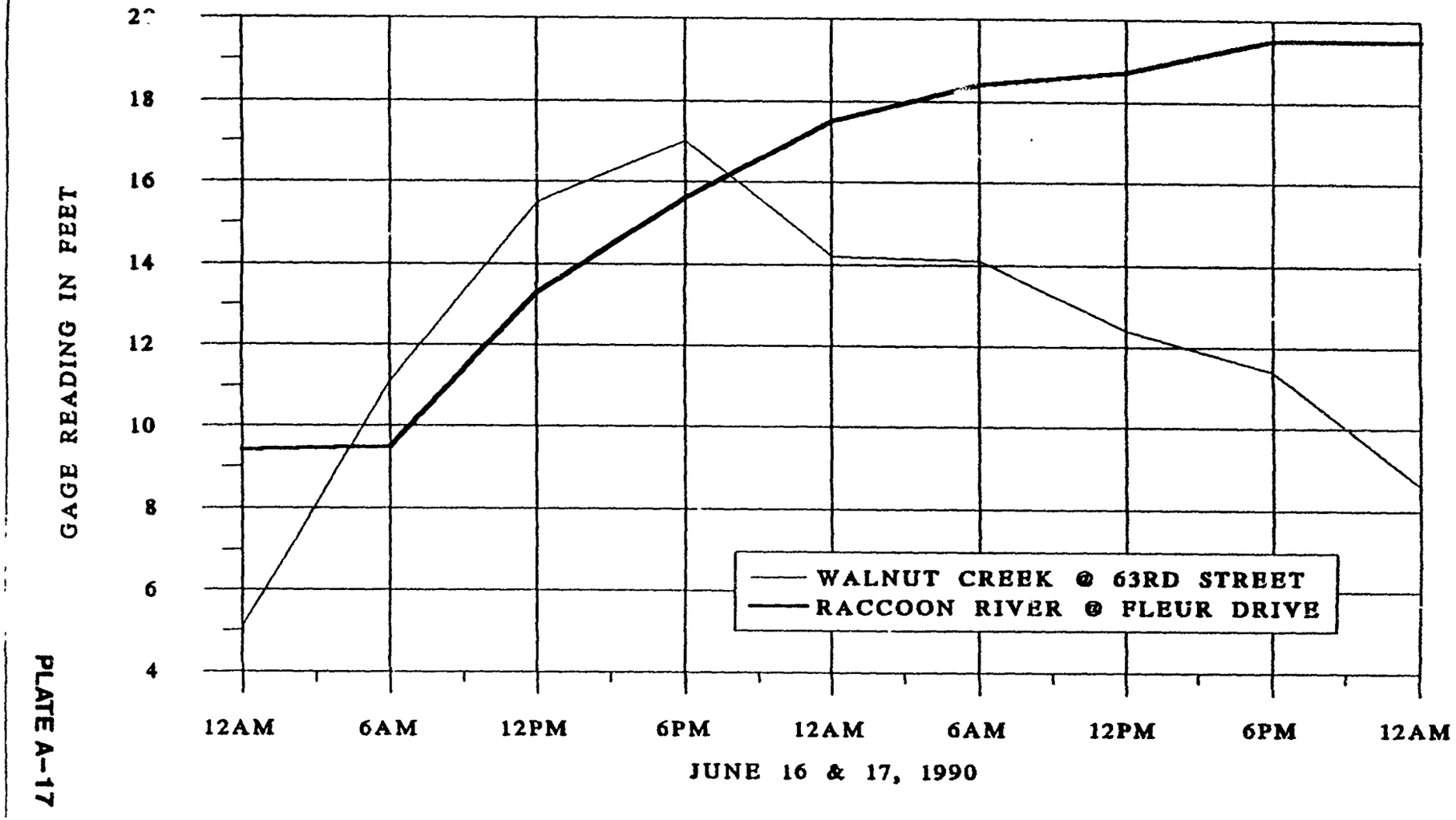
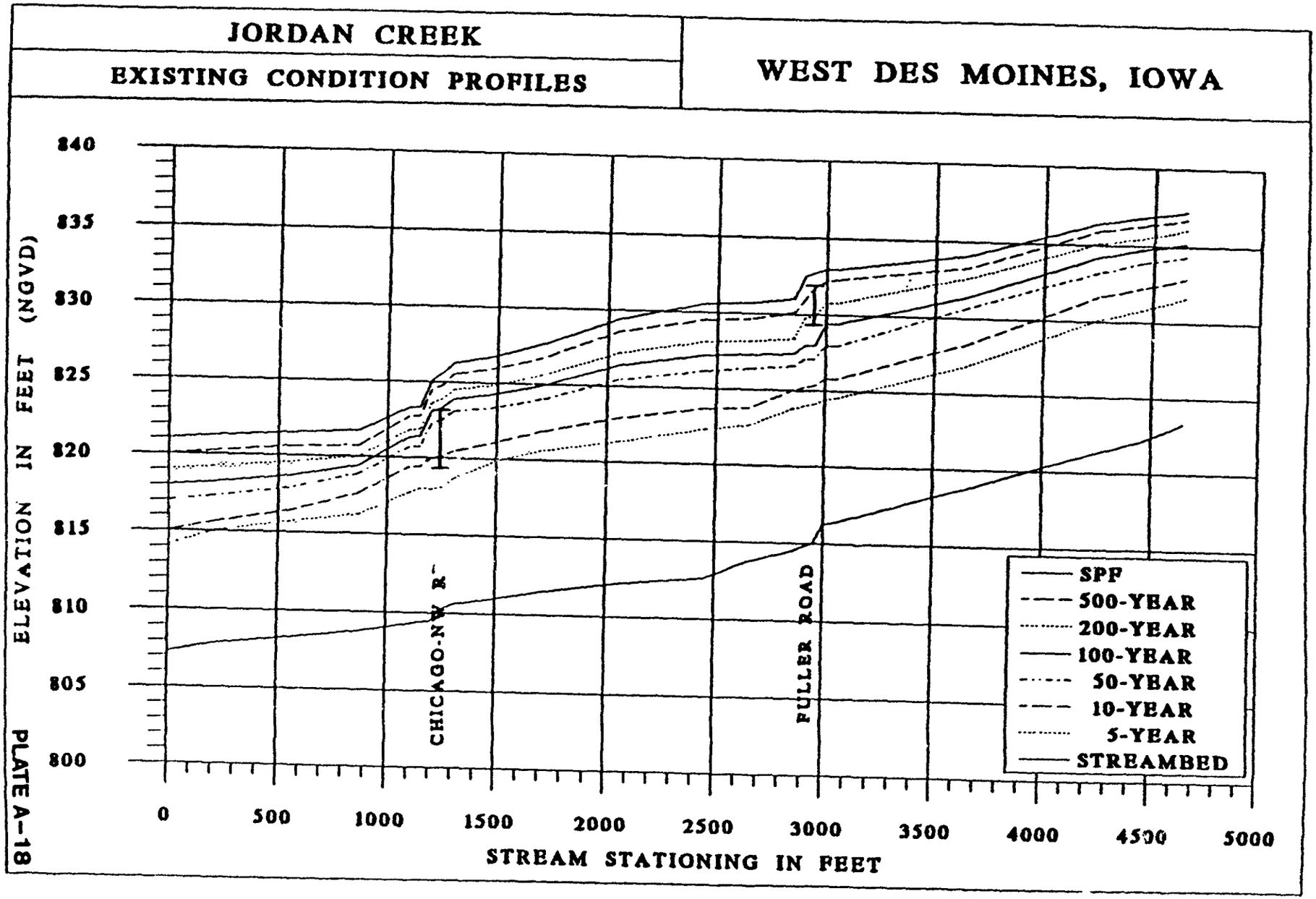


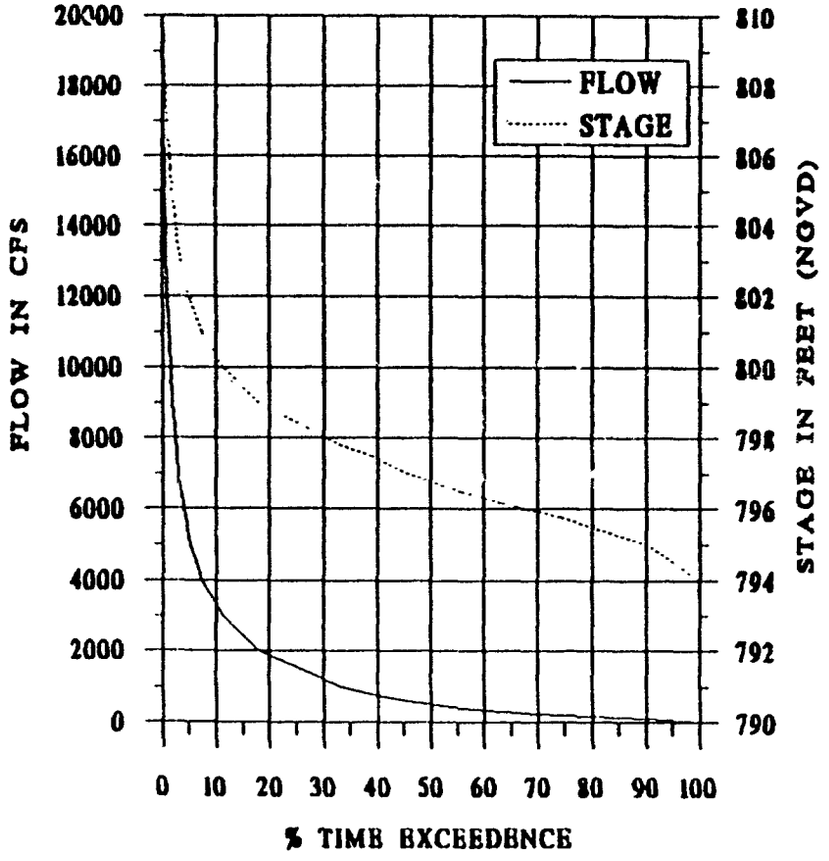
PLATE A-17


JORDAN CREEK
EXISTING CONDITION PROFILES
WEST DES MOINES, IOWA
ELEVATION IN FEET (NGVD)
840
835
830
825
820
815
810
805
800
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
STREAM STATIONING IN FEET
CHICAGO-NW R.
FULLER ROAD
SPF
500-YEAR
200-YEAR
100-YEAR
50-YEAR
10-YEAR
5-YEAR
STREAMBED
PLATE A-18

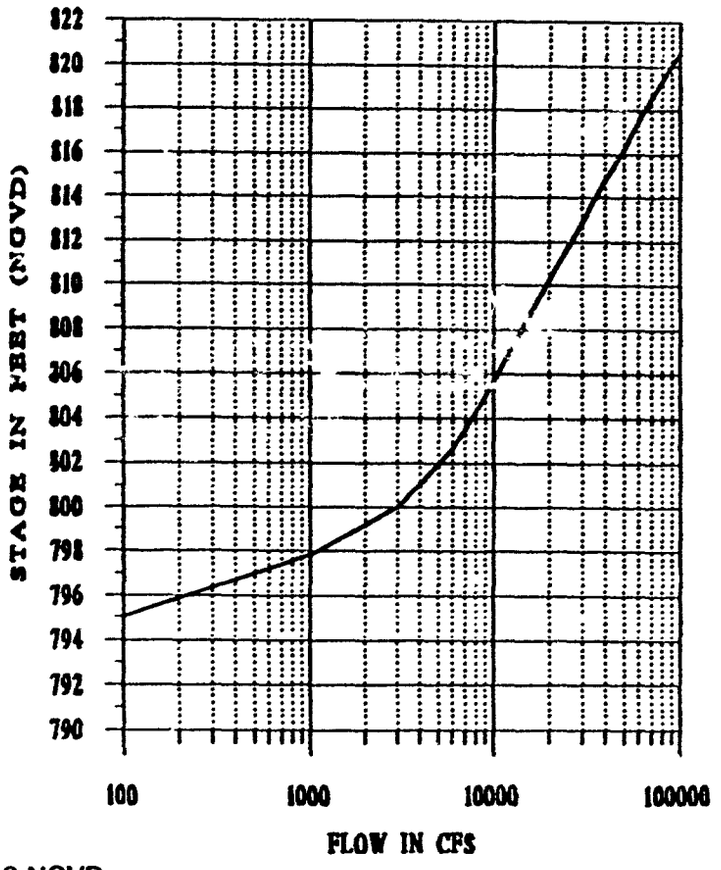
RACCOON RIVER	WEST DES MOINES, IOWA
FLOW DURATION, STAGE DURATION & RATING CURVE	

UPSTREAM OF 63RD STREET

FLOW & STAGE VS DURATION



RATING CURVE @ R.M. 210.6



0.0 CITY DATUM = 773.8 NGVD

PLATE A-19

WALNUT CREEK

FLOW DURATION, STAGE DURATION & RATING CURVE

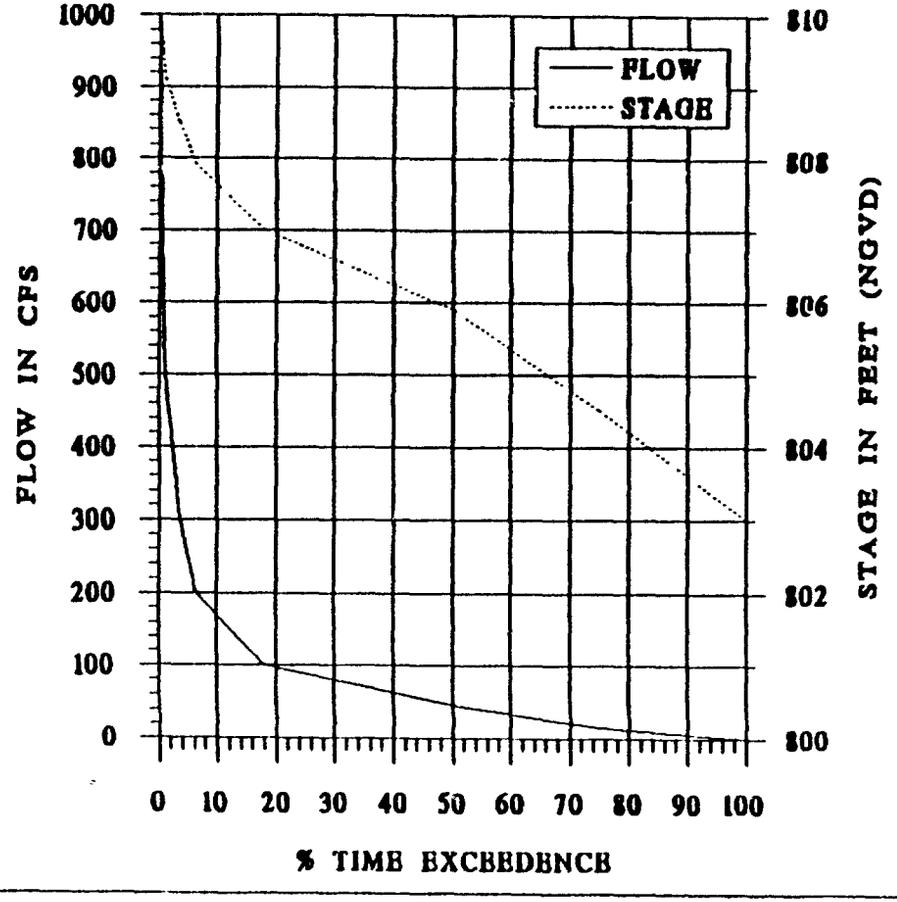
WEST DES MOINES, IOWA

0.0 CITY DATUM = 773.8 NGVD

0.0 GAGE DATUM = 27.2 CITY DATUM

DOWNSTREAM OF 63RD STREET

FLOW & STAGE VS DURATION



RATING CURVE @ USGS GAGE

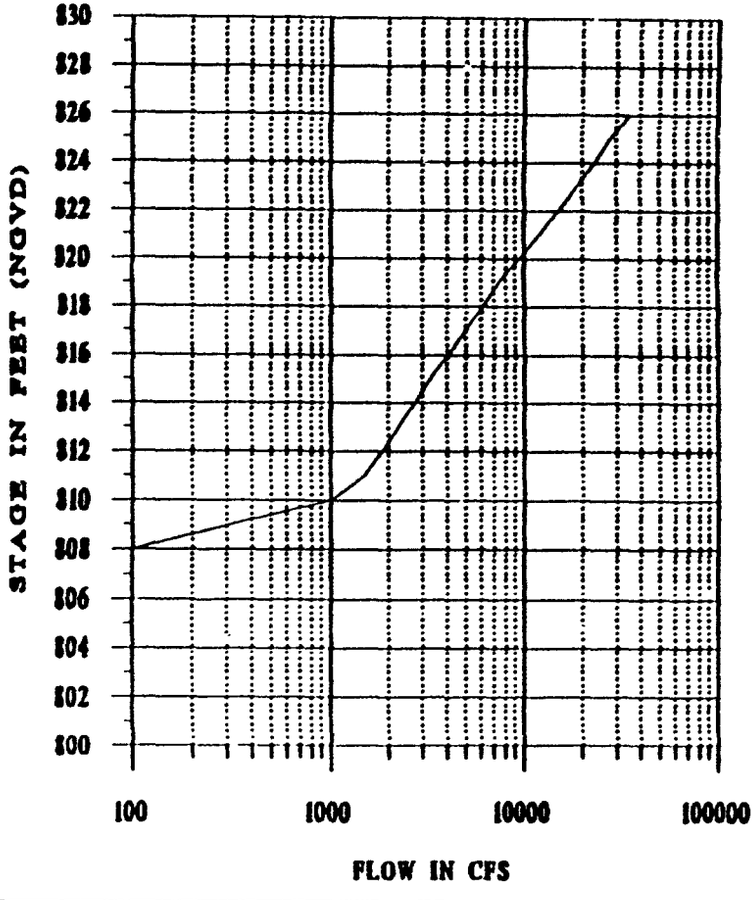


PLATE A-20

INTERIOR DRAINAGE AREAS

LOCATION MAP

WEST DES MOINES, IOWA

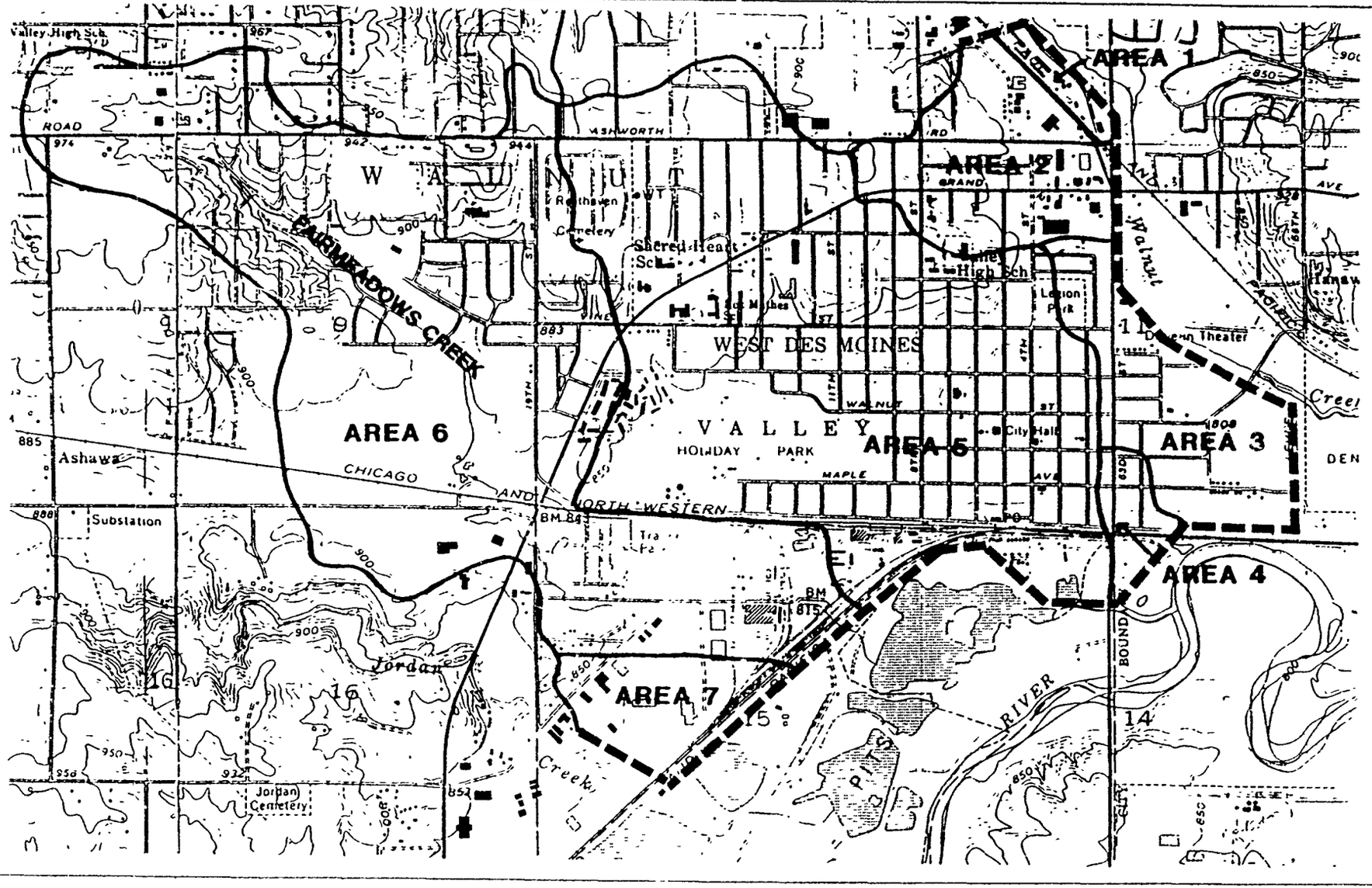


PLATE A-21

INTERIOR AREA 1

STAGE VS. STORAGE

WEST DES MOINES, IOWA

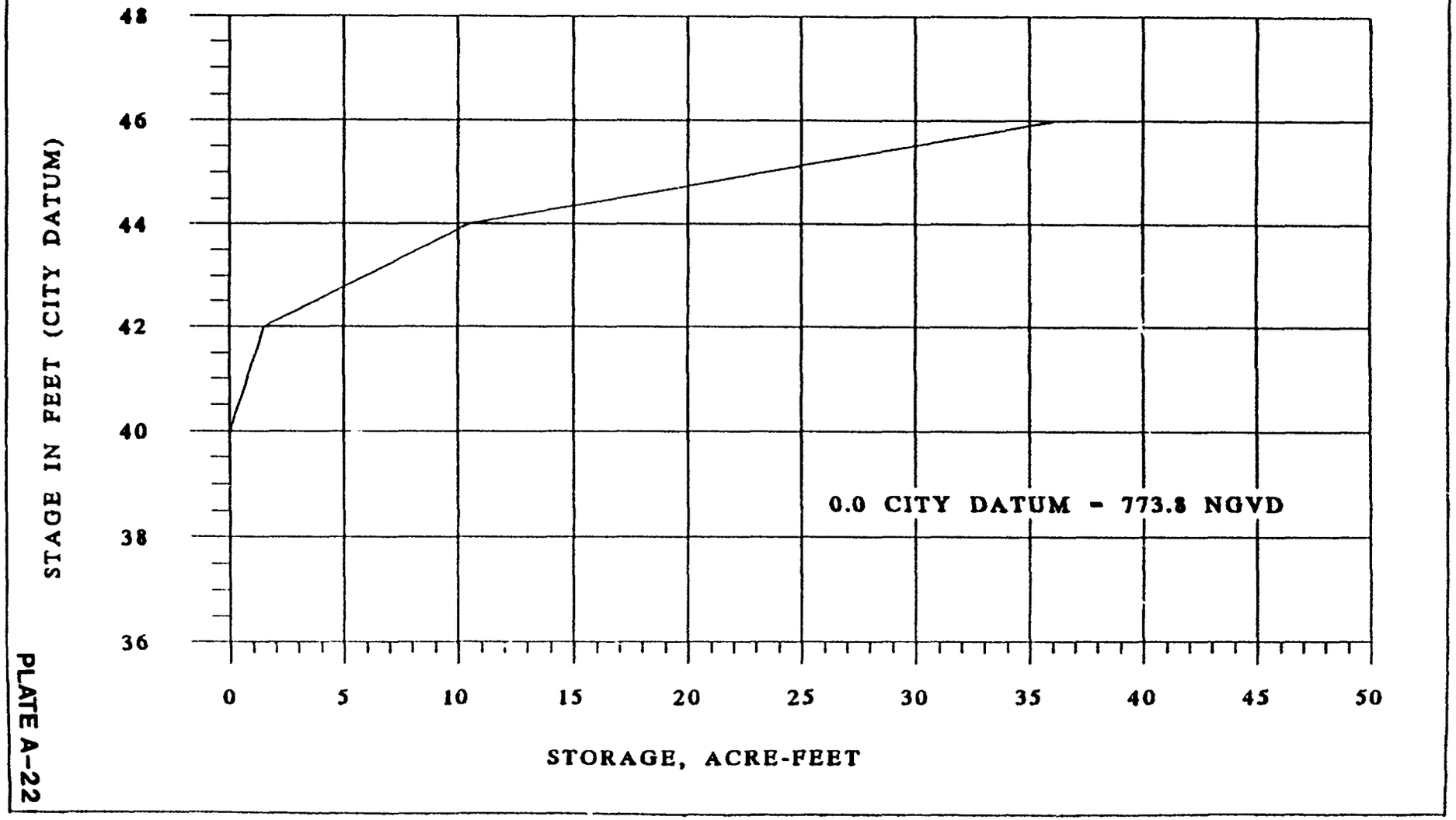


PLATE A-22

INTERIOR AREA 1

PONDING STAGE VS. FREQUENCY

WEST DES MOINES, IOWA

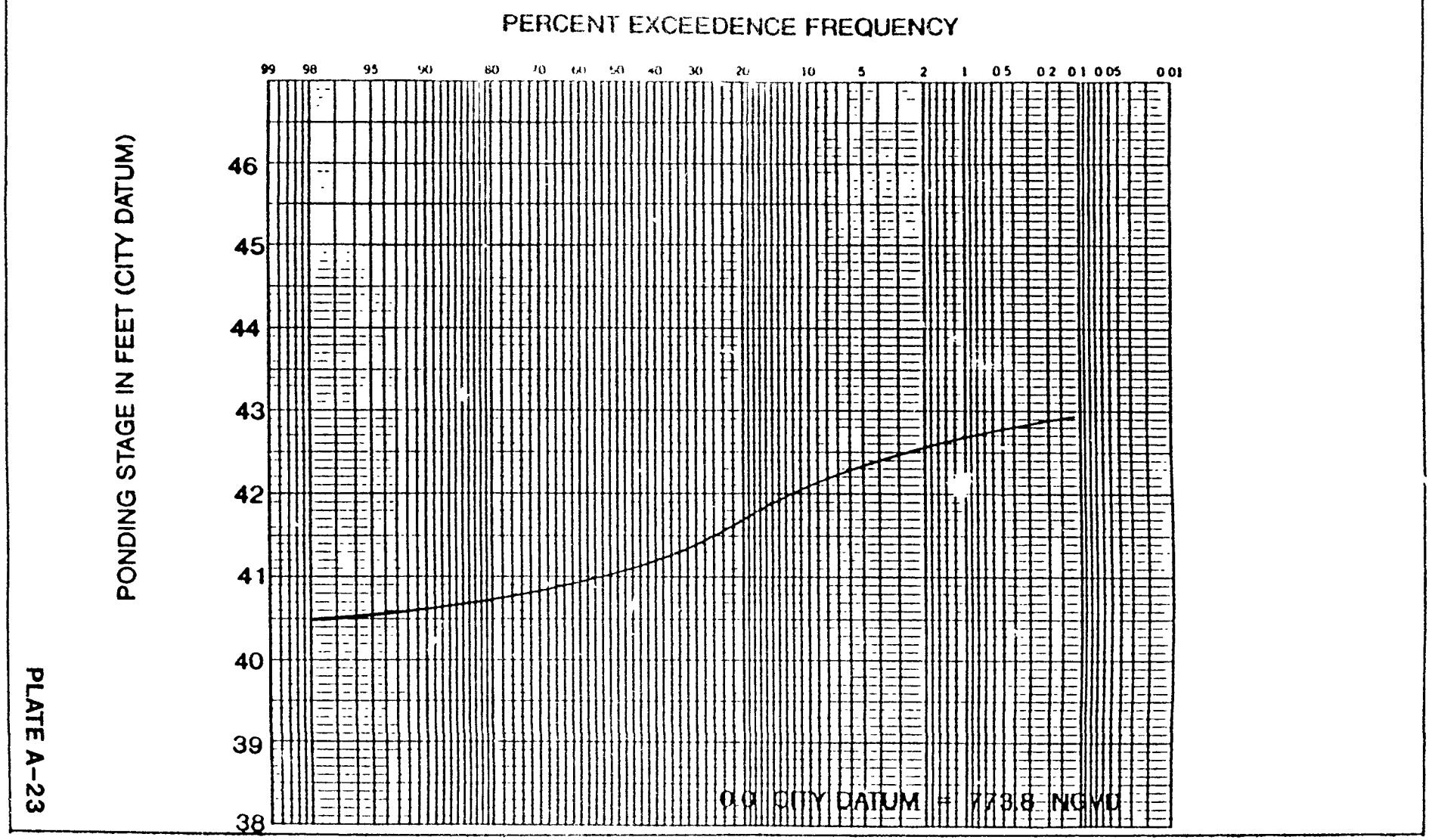


PLATE A-23

INTERIOR AREA 2

STAGE VS. STORAGE

WEST DES MOINES, IOWA

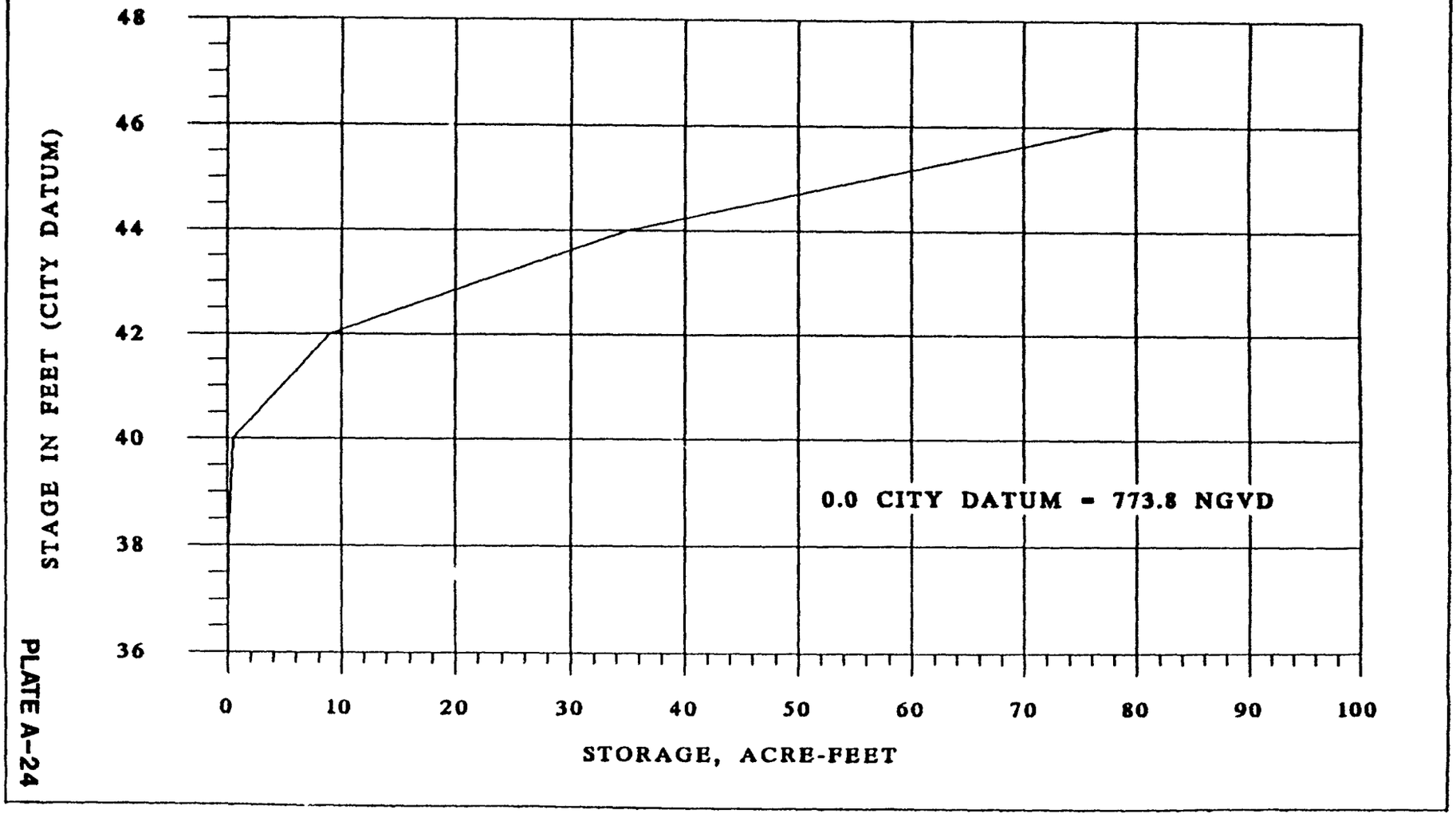


PLATE A-24

INTERIOR AREA 2

PONDING STAGE VS. FREQUENCY

WEST DES MOINES, IOWA

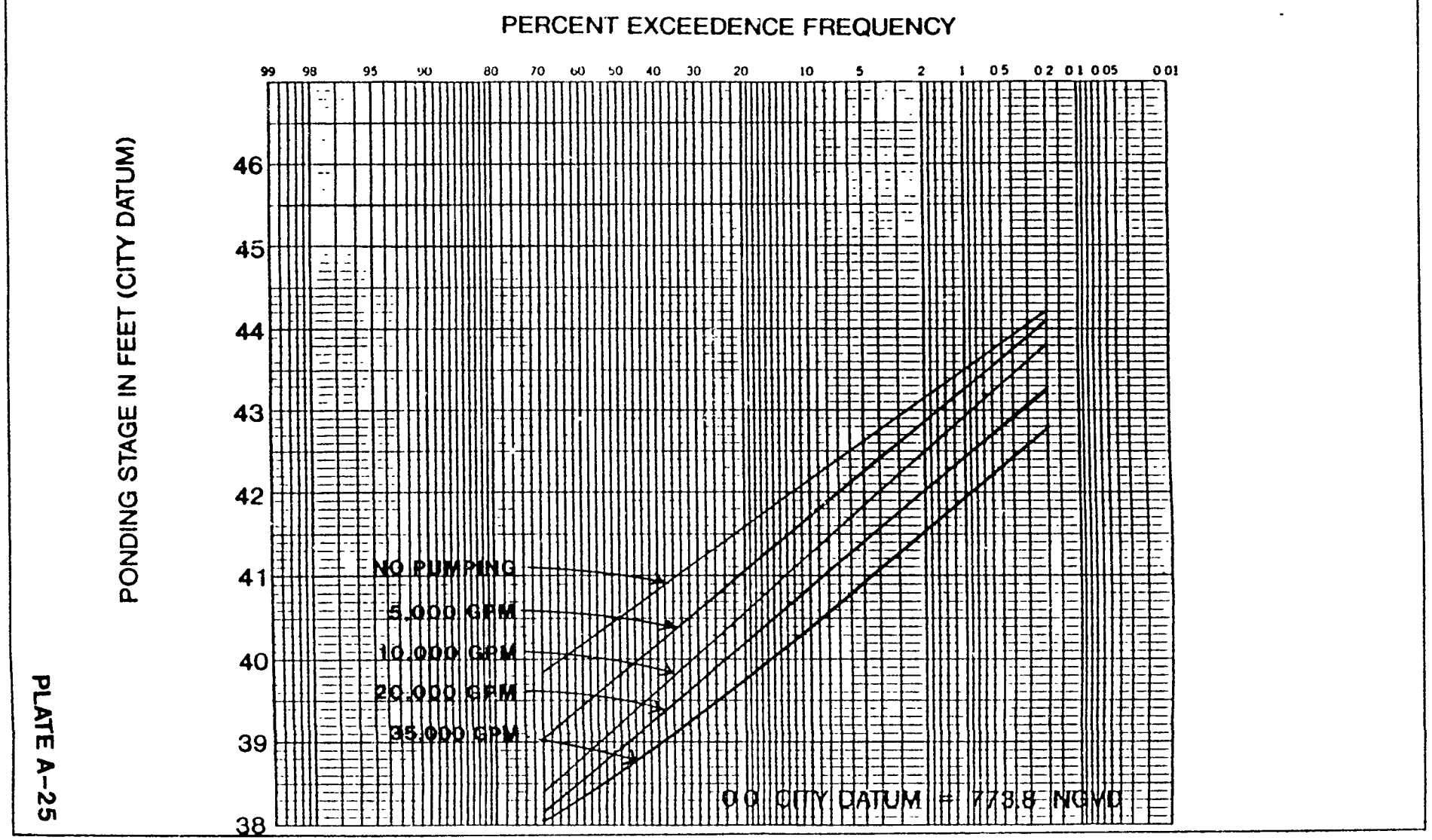


PLATE A-25

INTERIOR AREA 3

STAGE VS. STORAGE

WEST DES MOINES, IOWA

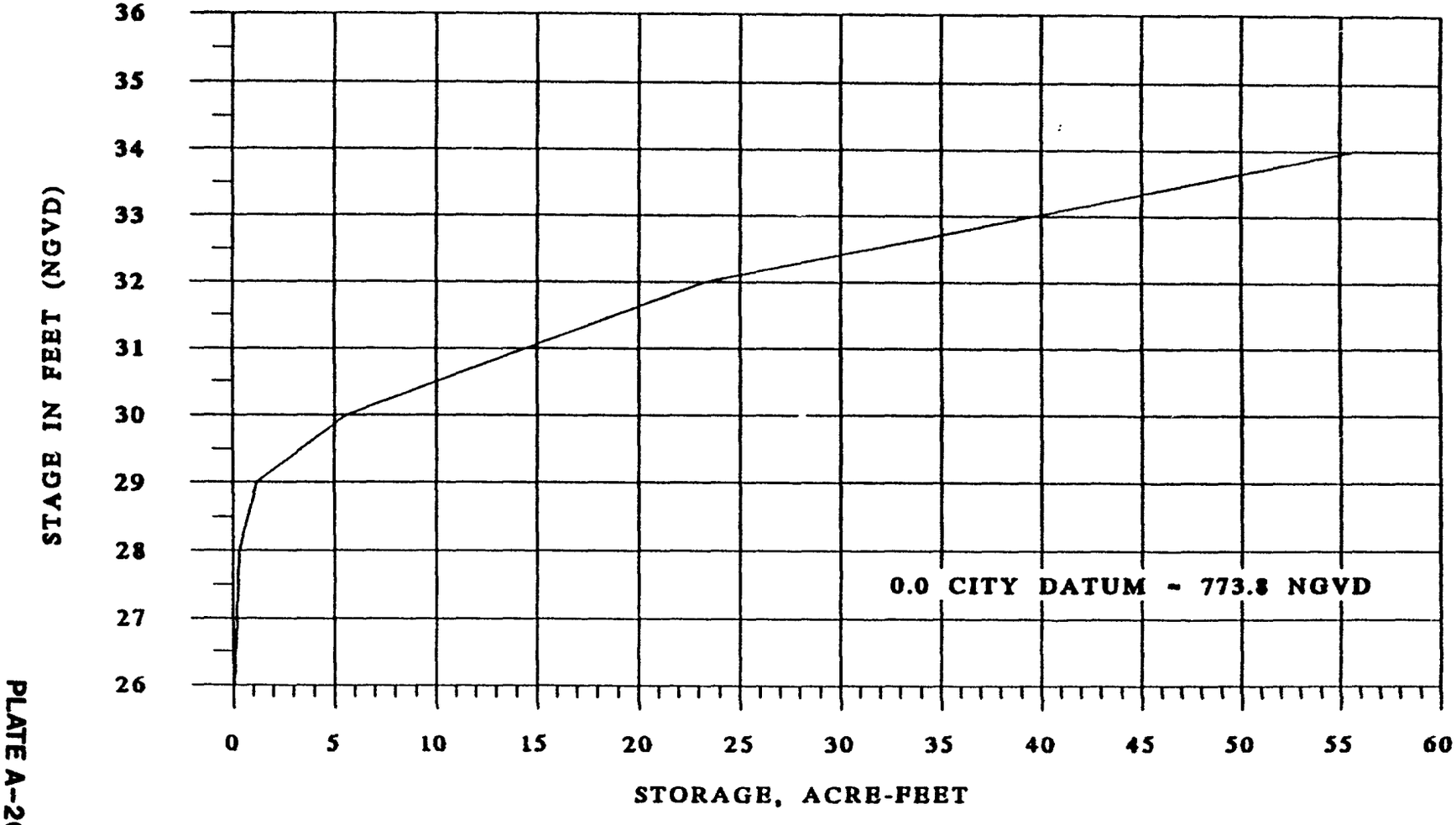


PLATE A-26

INTERIOR AREA 3

PONDING STAGE VS. FREQUENCY

WEST DES MOINES, IOWA

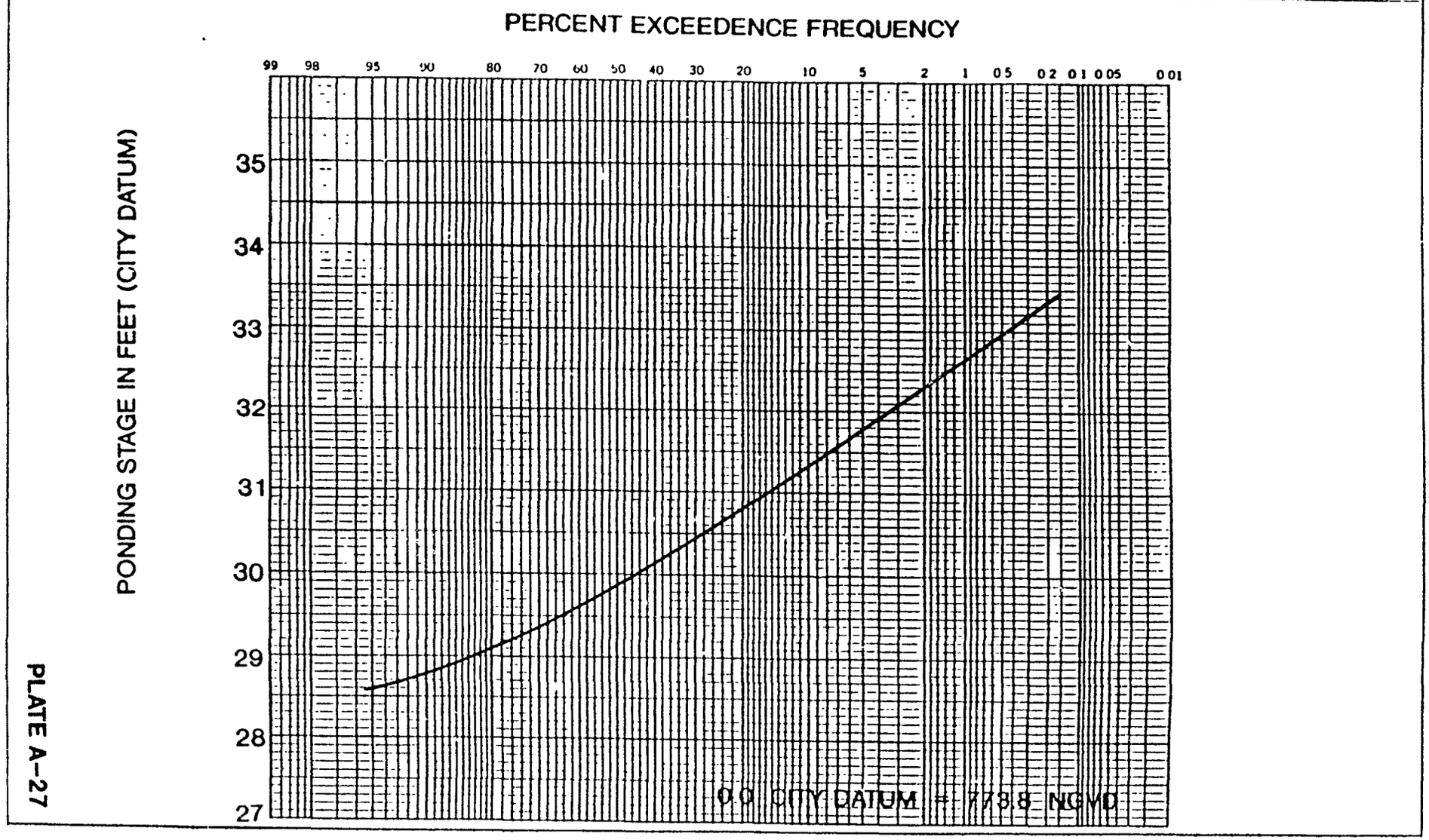


PLATE A-27

INTERIOR AREA 4

STAGE VS. STORAGE

WEST DES MOINES, IOWA

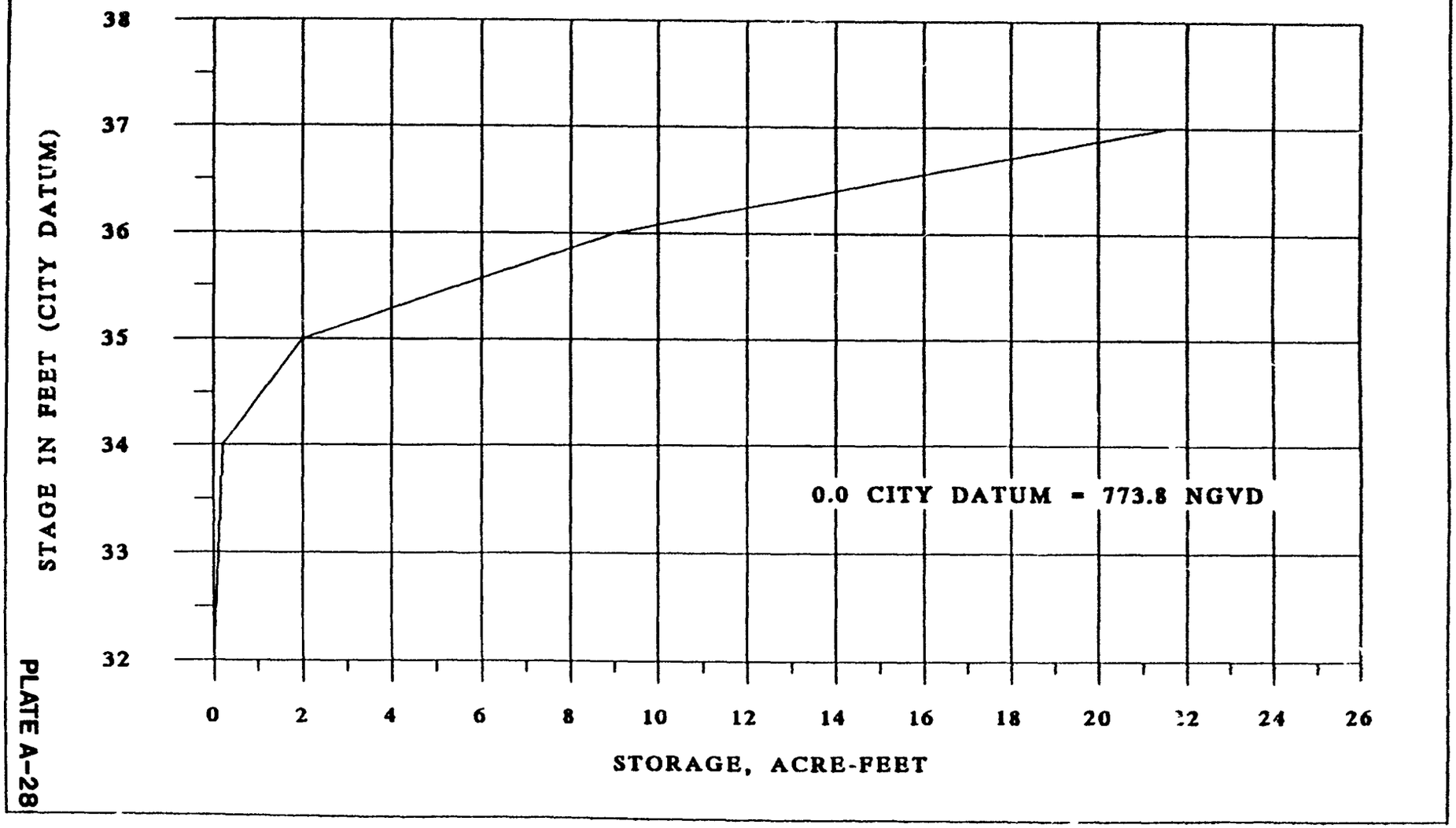


PLATE A-28

INTERIOR AREA 4	WEST DES MOINES, IOWA
PONDING STAGE VS. FREQUENCY	

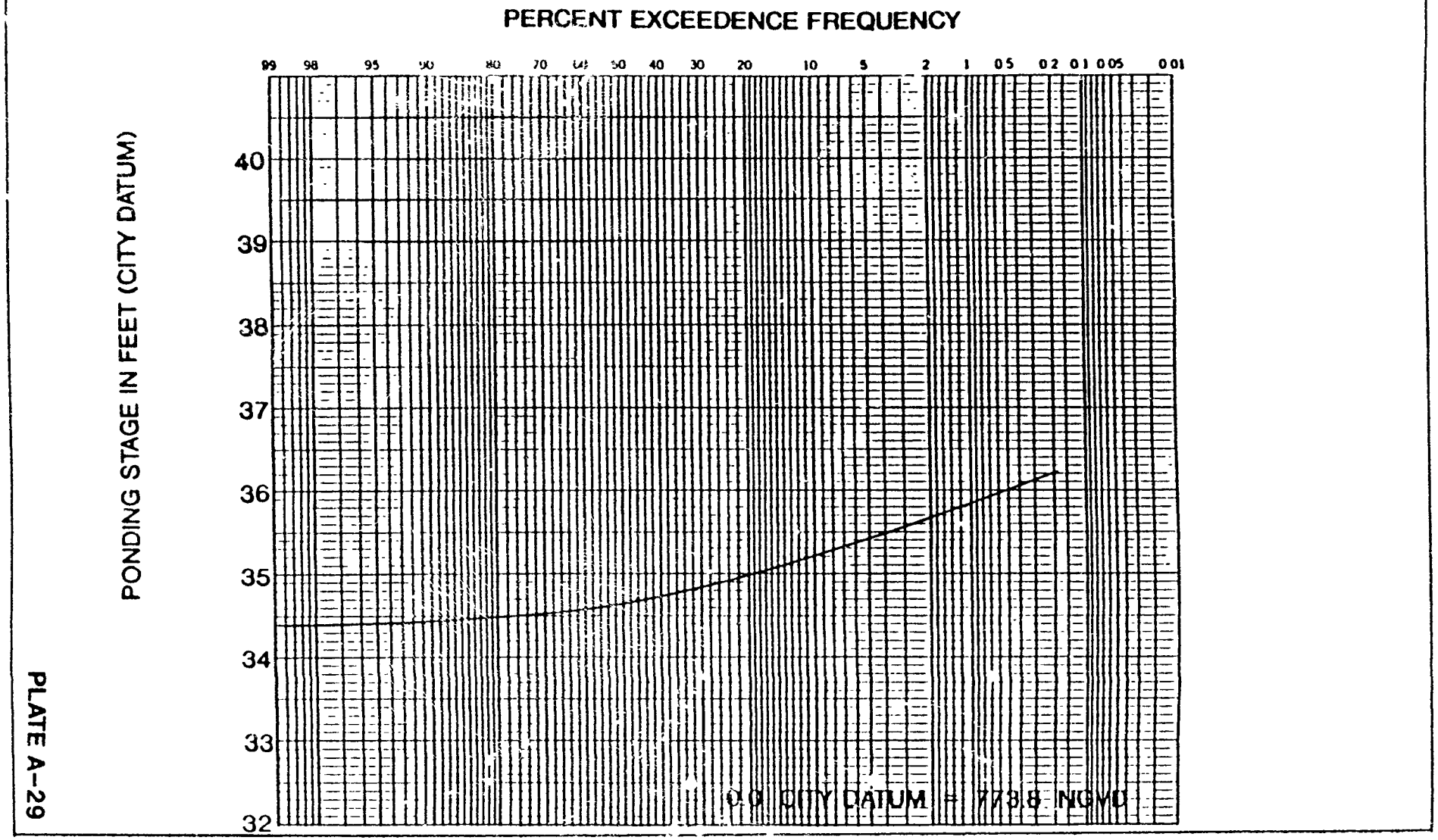


PLATE A-29

INTERIOR AREA 5

STAGE VS. STORAGE

WEST DES MOINES, IOWA

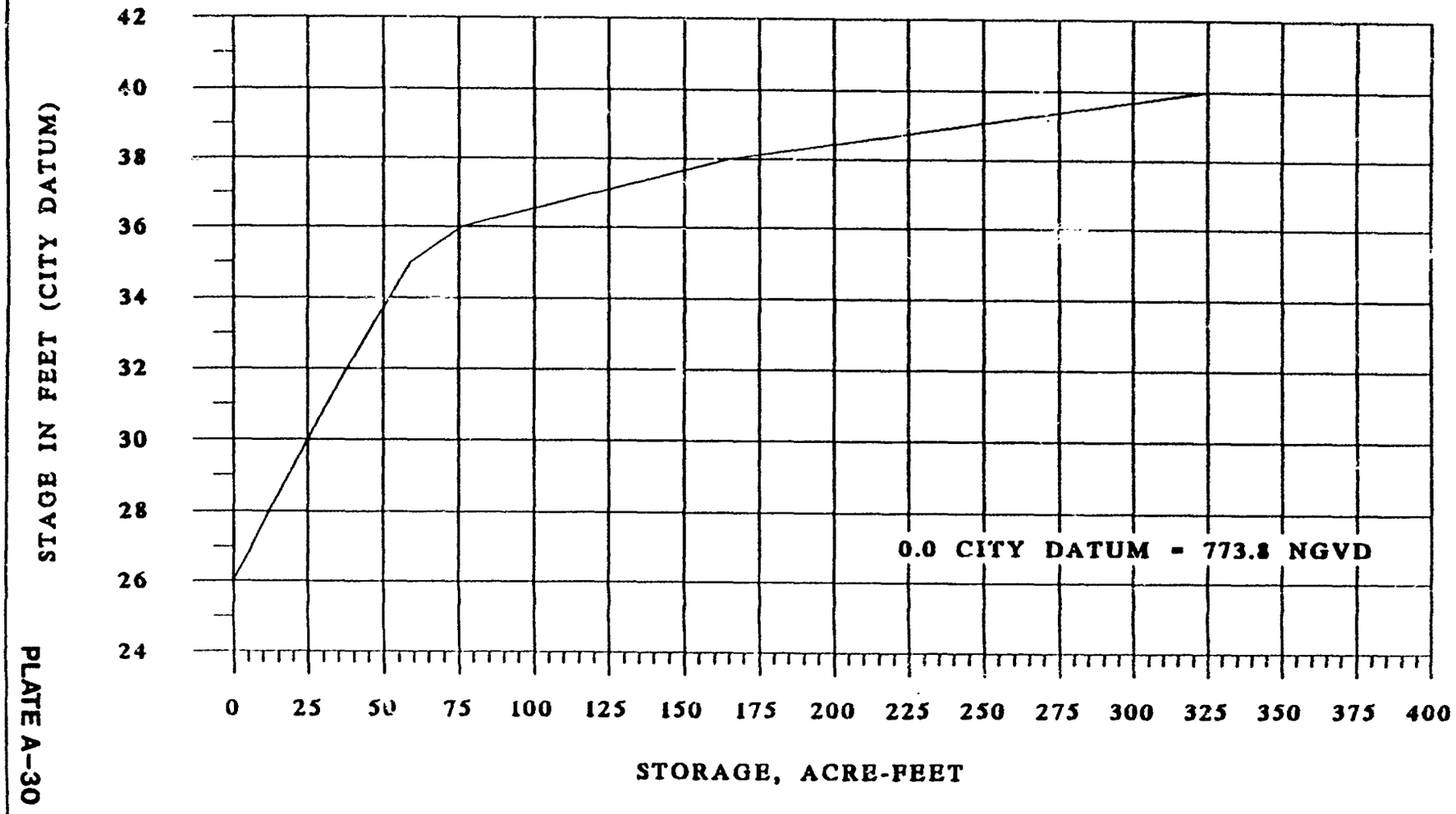


PLATE A-30

INTERIOR AREA 5	WEST DES MOINES, IOWA
PONDING STAGE VS. FREQUENCY	

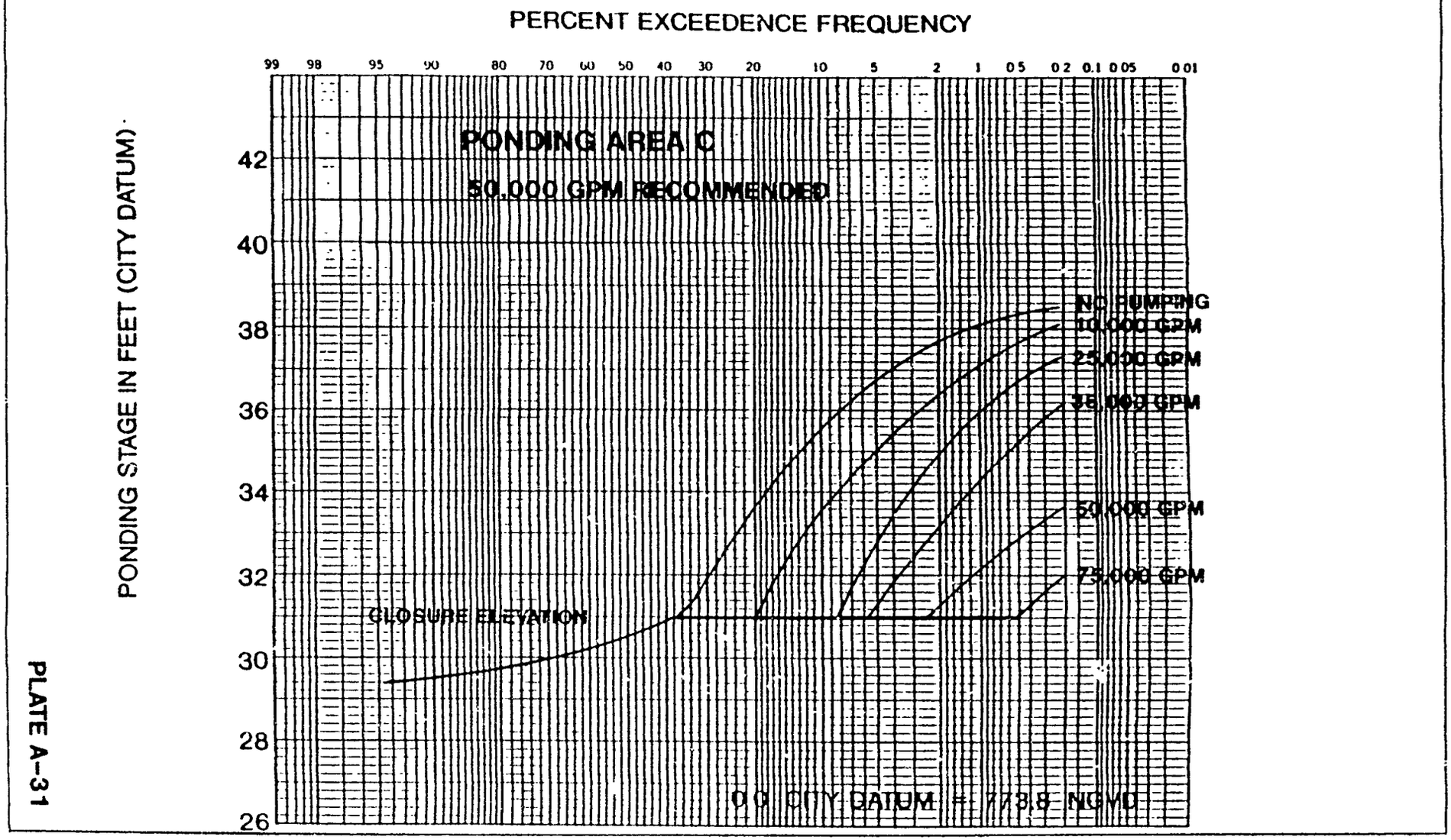


PLATE A-31

INTERIOR AREA 6

STAGE VS. STORAGE

WEST DES MOINES, IOWA

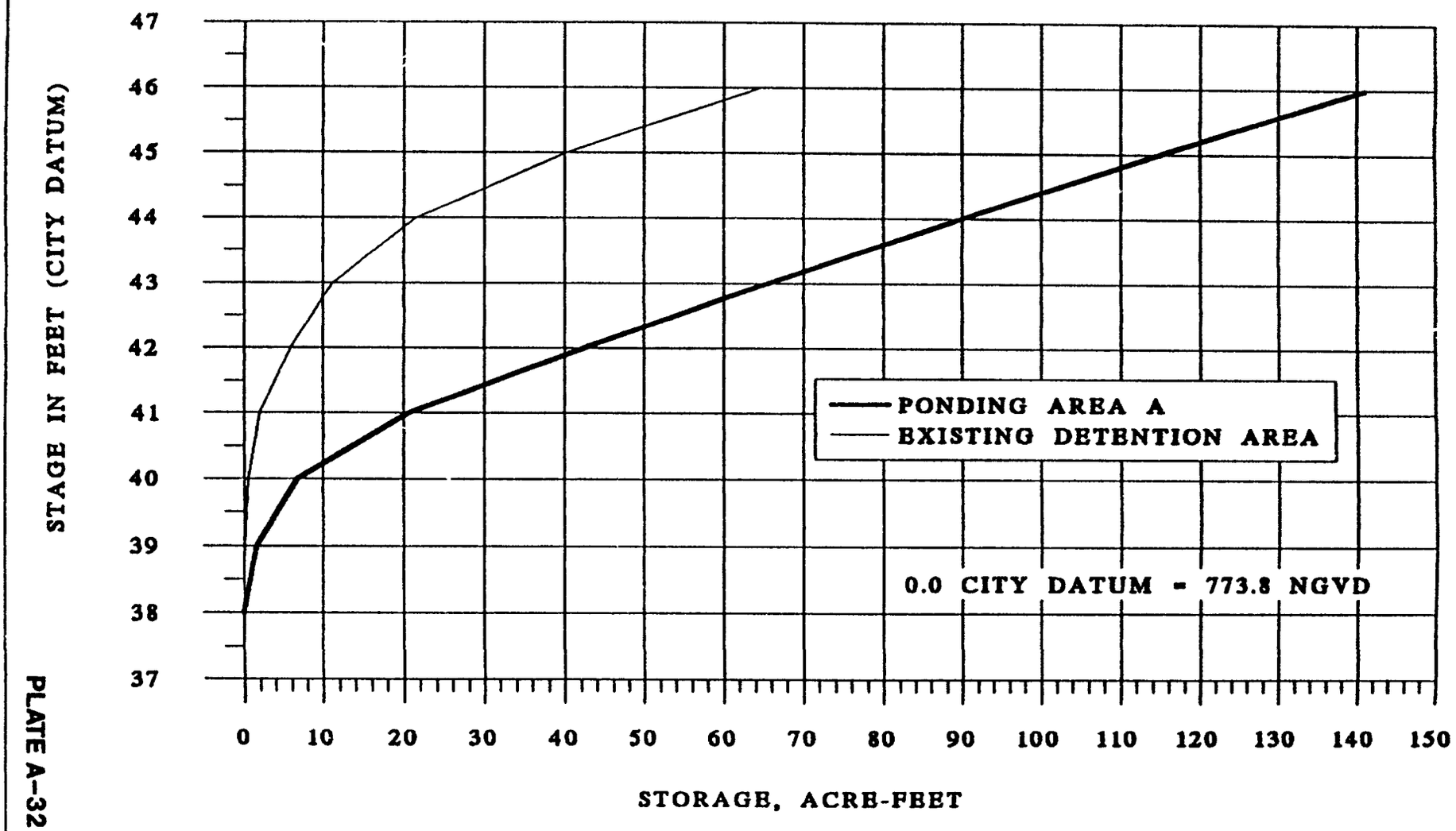


PLATE A-32

INTERIOR AREA 6

PONDING STAGE VS. FREQUENCY

WEST DES MOINES, IOWA

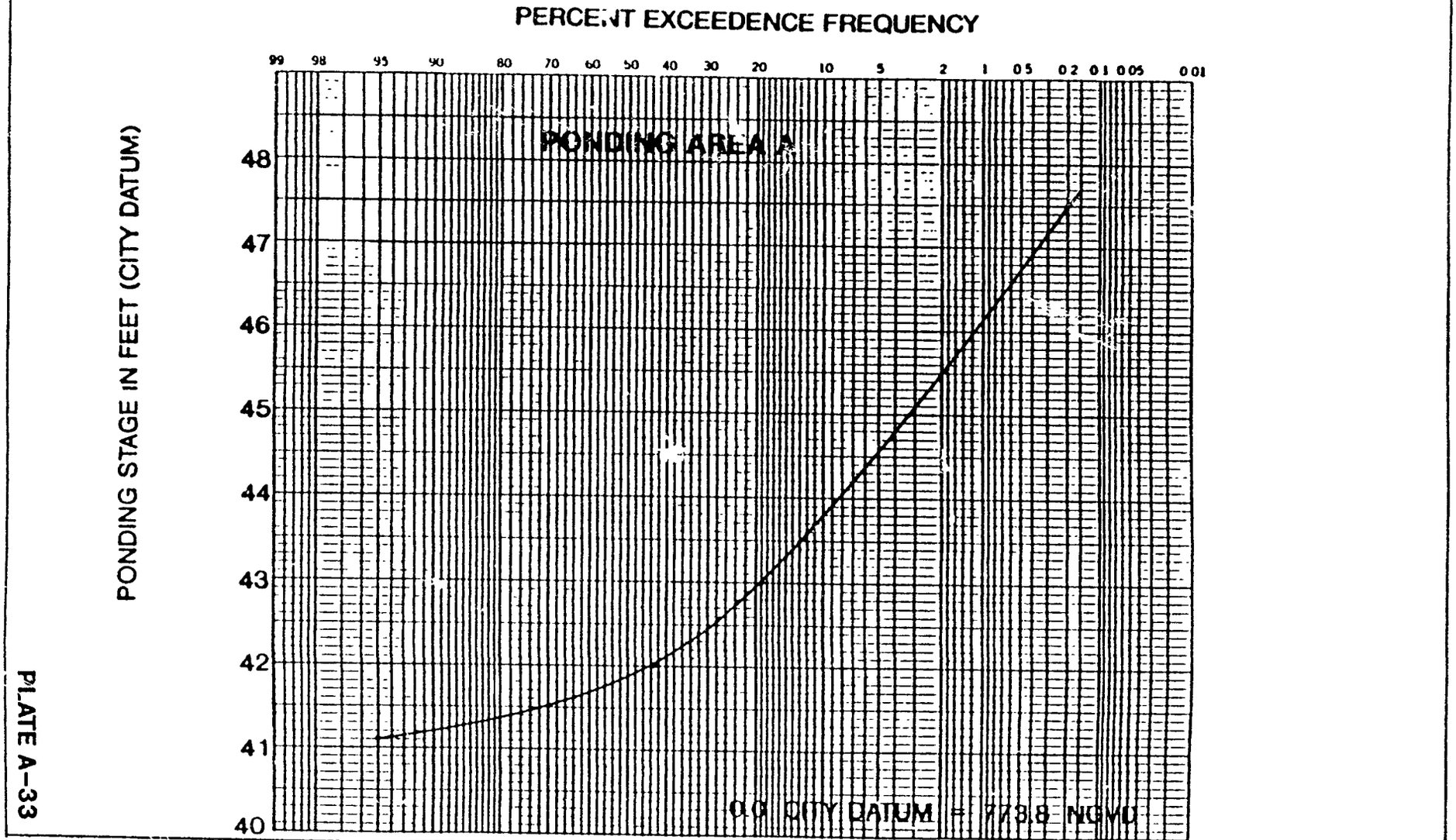


PLATE A-33

INTERIOR AREA 7

STAGE VS. STORAGE

WEST DES MOINES, IOWA

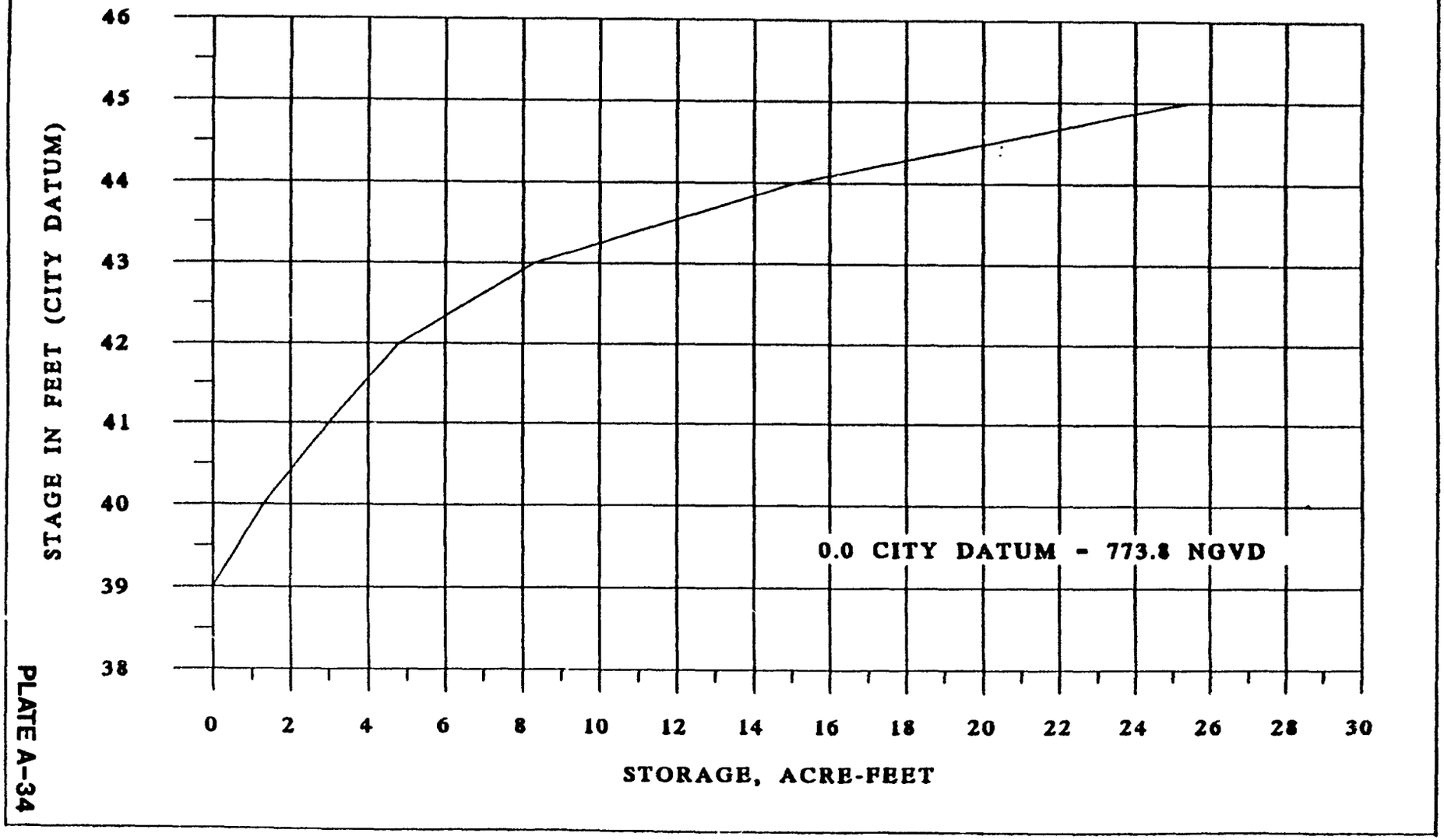


PLATE A-34

INTERIOR AREA 7	WEST DES MOINES, IOWA
PONDING STAGE VS. FREQUENCY	

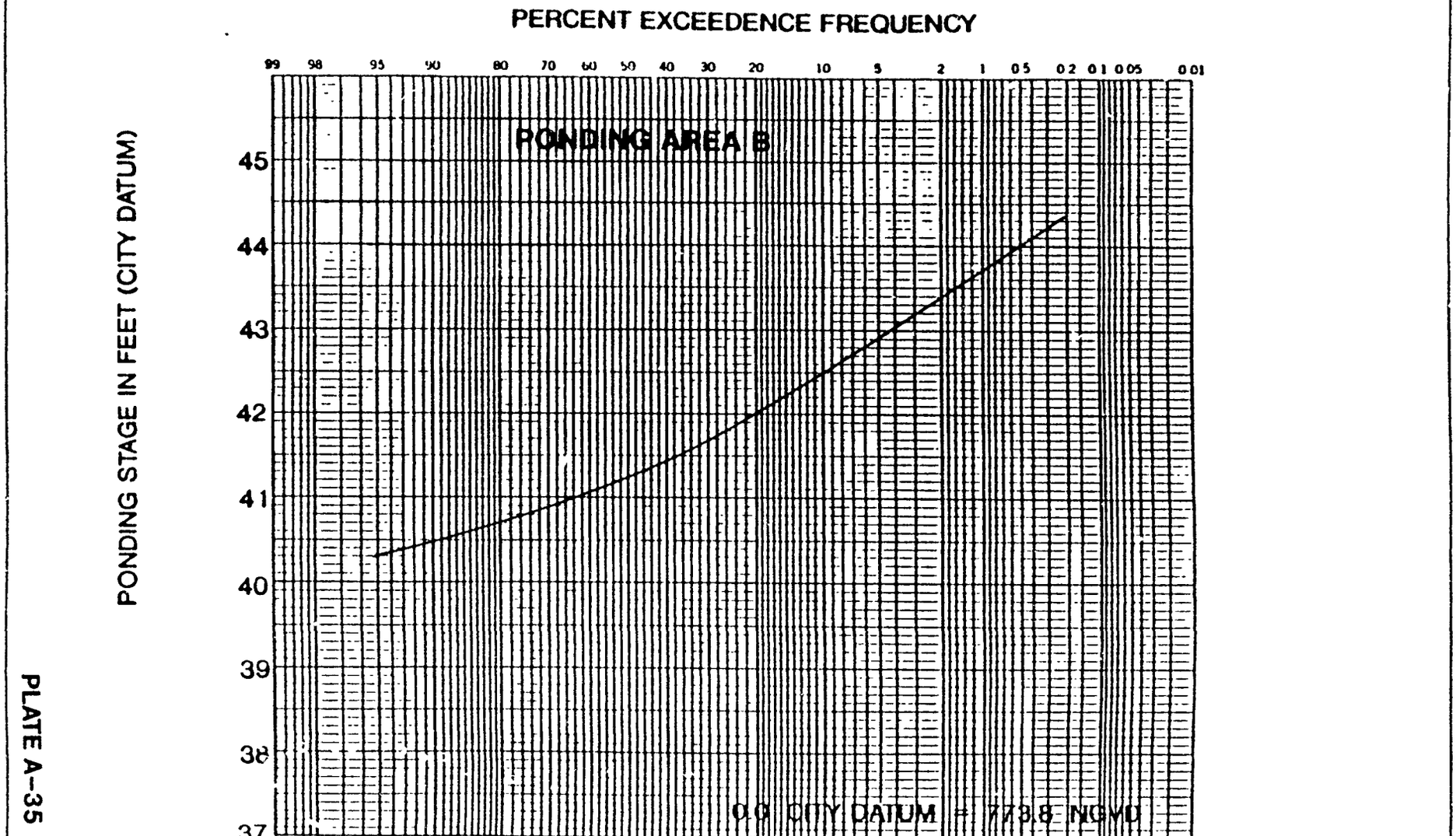


PLATE A-35

FIGURE 4

FLOW FOR CIRCULAR PIPE FLOWING FULL
BASED ON MANNING'S EQUATION n=0.012

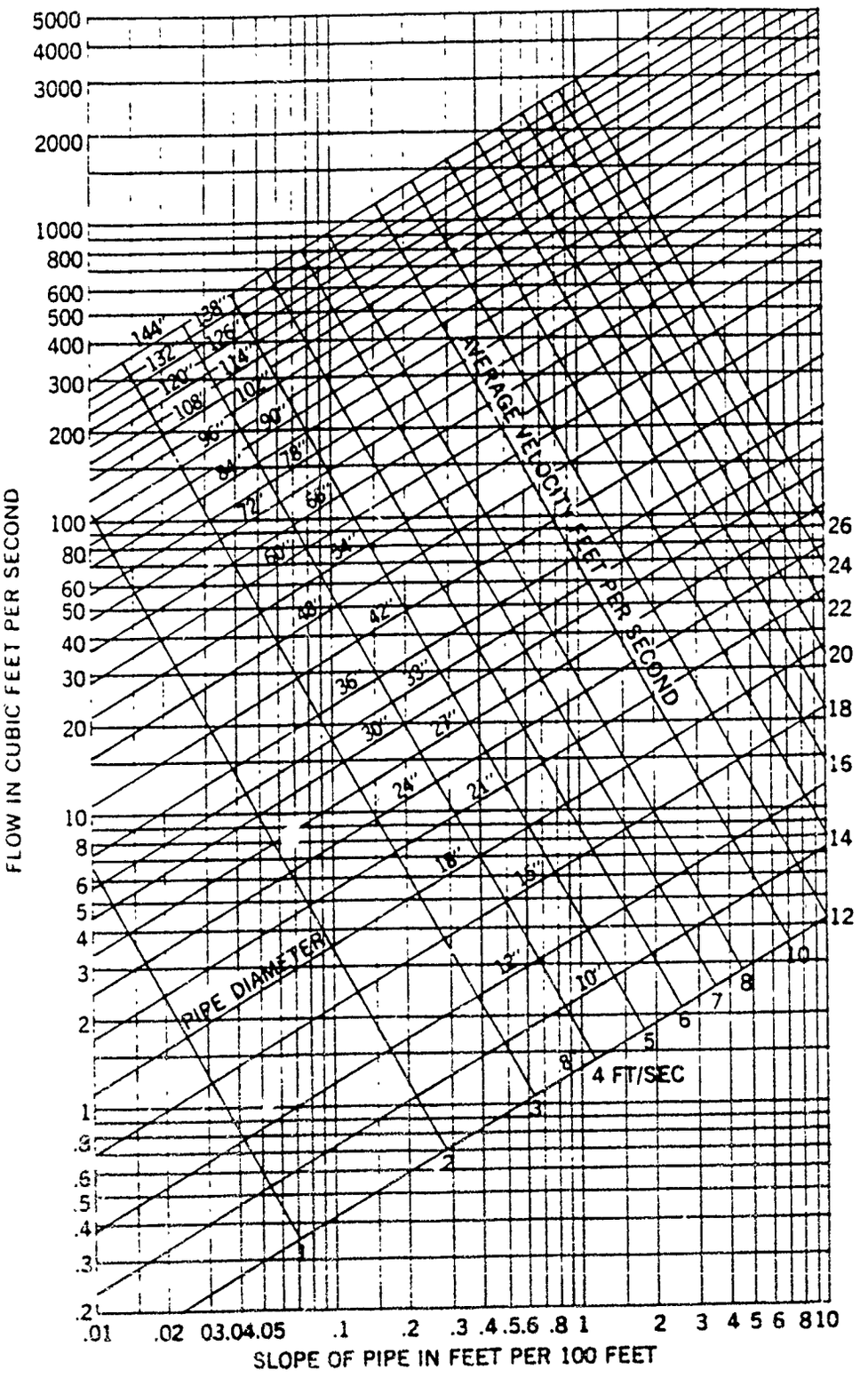


PLATE A-36

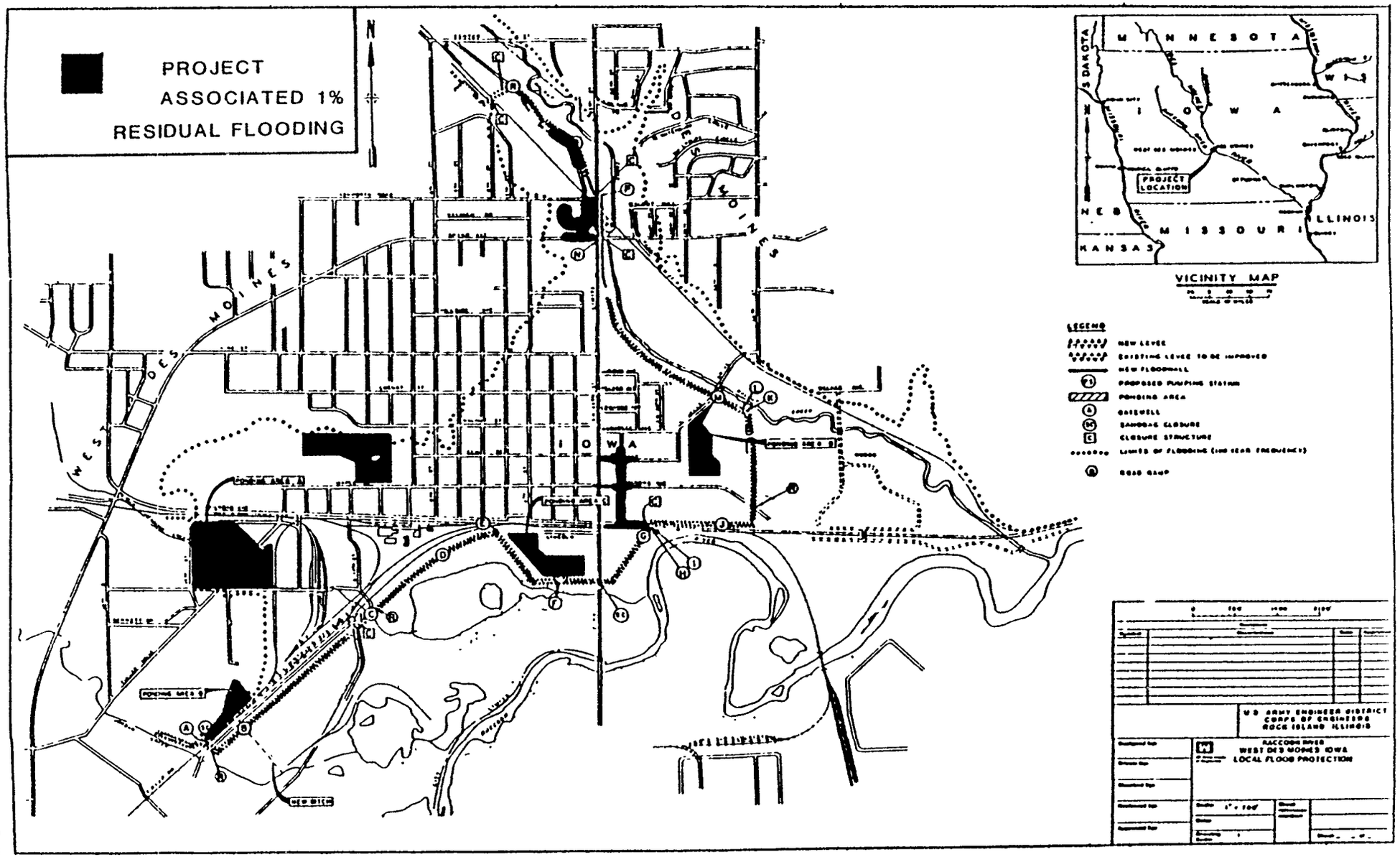
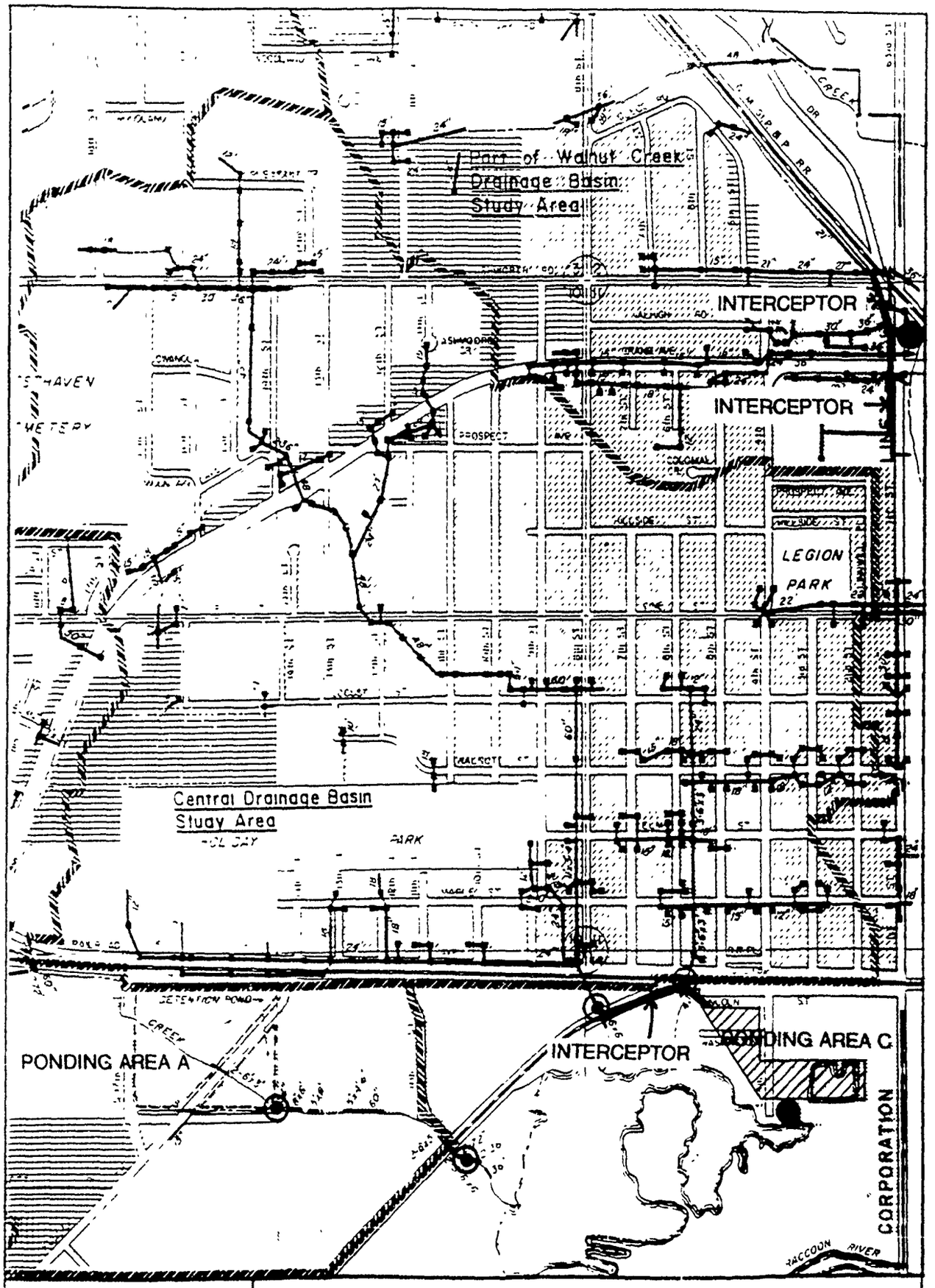

PROJECT
ASSOCIATED 1%
RESIDUAL FLOODING
N
DES MOINES
WEST DES MOINES
IOWA
VICINITY MAP
MINNESOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
MISSOURI
ILLINOIS
PROJECT LOCATION
LEGEND
NEW LEVEE
EXISTING LEVEE TO BE IMPROVED
NEW FLOODWALL
PROPOSED PUMPING STATION
PONDING AREA
GATEWELL
SANDBAG CLOSURE
CLOSURE STRUCTURE
LIMITS OF FLOODING (100 YEAR FREQUENCY)
ROAD RAISE
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND ILLINOIS
RACCOON RIVER
WEST DES MOINES IOWA
LOCAL FLOOD PROTECTION

PLATE A-37

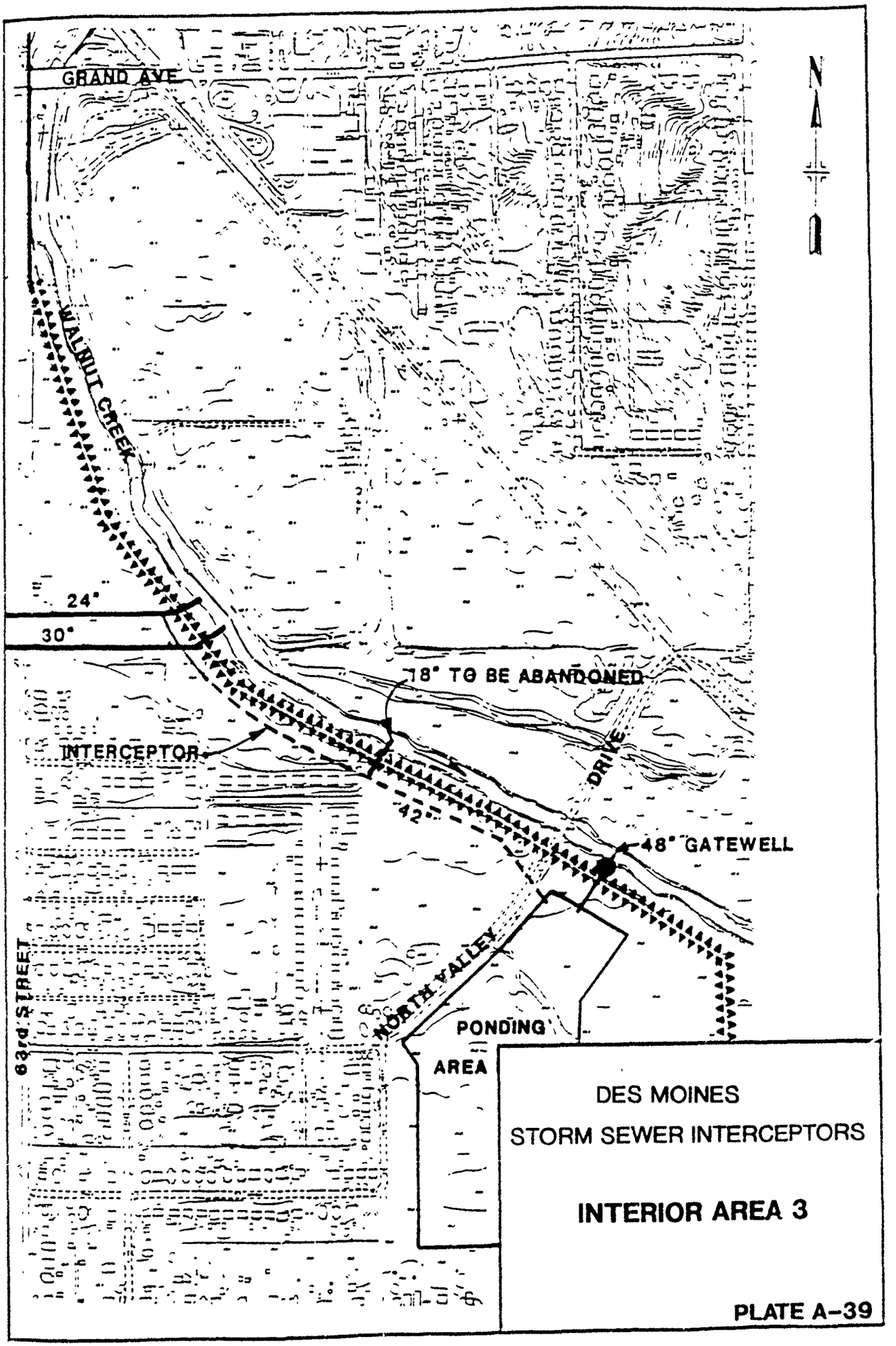


PUMP STATION

GATEWELL

WEST DES MOINES STORM SEWER INTERCEPTORS

PLATE A-38


GRAND AVE
WALNUT CREEK
24"
30"
78" TO BE ABANDONED
INTERCEPTOR
42"
DRIVE
48" GATEWELL
63rd STREET
NORTH VALLEY
PONDING
AREA
N
DES MOINES
STORM SEWER INTERCEPTORS
INTERIOR AREA 3
PLATE A-39

APPENDIX A
HYDROLOGY AND HYDRAULICS

ADDENDUM A

FLOOD WARNING / FLOOD RESPONSE

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B	Early Warning Weather ALERT System
C	Flood Advisory Tables
D	National Weather Service Bulletin
E	Basin Index Rainfalls

ADDENDUM A

FLOOD WARNING / FLOOD RESPONSE

FLOOD WARNING

The West Des Moines/Des Moines local flood protection project will only be fully operational if advance warning of impending flooding is made available to the communities. Levee and gatewell closures will need to be made on a timely schedule in order for the line-of-protection to be whole. Thus, the purpose of the flood warning system is to provide city emergency service personnel with advance flood information that can be readily translated into response measures.

The flood response measures to a flood situation are dependent on the type of protection available to the cities. Presently, with no comprehensive levee project for this area, the locals actions are limited to flood-fighting activities on the Raccoon River such as placing sandbags and temporary earth berms to hold back intermediate floods. This was successfully done during the July 1986 flood due to an advance warning. On Walnut Creek, flash flooding limits local responses mainly to evacuations and utility shutoffs. Even these limited damage reduction measures were severely constrained by a lack of information during the May 1986 flood on Walnut Creek.

The cities of Des Moines, West Des Moines and Clive recognized the need for timely and accurate flood warning information as a result of the 1986 Walnut Creek flood. Additional advance warning time would allow for crucial additional response time. Evacuations could be made before the on-set of flooding, individual flood-fighting measures could be put in-place and emergency services could be alerted and placed on standby.

In 1987, the three communities entered into a Memorandum of Understanding For a Community Sponsored Automated Flood Warning System with the National Weather Service. This memorandum is included as Attachment A. The memorandum was undertaken for the purpose of defining a mutual assistance program designed to provide advance flood warning for the metropolitan areas of Des Moines, Iowa. The memorandum spelled out authorities, agreements, responsibilities, and funding of a system including the establishment of a maintenance fund.

During 1987 and 1988, the communities along with the assistance of the NWS evaluated the advance flood warning alternatives available. System formulation included Rock Island District involvement in the layout of the plan. The intent and result was to have a fully compatible, approved flood warning system which could be incorporated into the project needs of any future Corps

of Engineers local flood protection project in the metropolitan area.

In January 1989, the City of Des Moines released a Notice To Bidders and Specifications which detailed an early warning weather alert system based on the Automated Local Evaluation in Real Time (ALERT) system. The Specification are included as Attachment B. The ALERT system was developed by the NWS California-Nevada River Forecast Center. The ALERT system consists of automatic reporting river and rainfall gages, a communications system based on line-of-sight radio transmission of data, a radio receiver, and a microprocessor network. The Des Moines system includes data analysis and display software to process, display, and control the quality of data. Additionally, the NWS River Forecast Center in St. Paul, Minnesota developed hydrologic models and flood advisory tables which provide peak streamflow and time to peak forecasts based on antecedent moisture conditions and observed rainfall depths.

The Des Moines ALERT system is designed to provide real-time rainfall and stream level data for Walnut Creek on the western side of the area, and Four Mile Creek in the northeast portion of Des Moines. Additionally, Des Moines River and Raccoon River streamflow data can be obtained. Data from the system will provide the communities involved with real-time information on which to base the decisions as to the proper response to a rainfall and potential flood event. The system will also provide the NWS data which will be used in the issuance of Flash Flood Warnings and Flood Advisories. The map on plate A-A shows the physical layout of the basin involved and the locations of the sensors in the ALERT system. Additional sketches and descriptions are found in Attachment B.

The system was installed during the summer of 1989 and became operational in November 1989. A March 13, 1990 rainfall and highwater event on Walnut Creek found the ALERT system to be fully operational and of great benefit to the metropolitan area of Des Moines. The city of Des Moines has agreed to be the designated lead agency and will coordinate the operation and maintenance of the system.

The following details the advance flood warning on each stream.

Raccoon River:

The Van Meter stream gage on the Raccoon River provides definitive advance flood warning to downstream areas. The rate of rise to peak at Van Meter is typically greater than 24 hours for major floods and the travel time to the project area is 15 hours. The NWS office in Des Moines also provides flood forecasting on the Raccoon River basin which yields an advance notice of flooding based on observed rainfall of 1-2 days. Relationships of stages at Van Meter to expectant stages at West Des Moines have been established in the past; typically at 63rd

Street in West Des Moines, 0.0 feet Van Meter gage datum + 18.0 = expectant stage in city datum. The local drainage area between Van Meter and West Des Moines is of insufficient size to create significant increases in flooding at the project site. Thus, 2 or more days of advance warning time is available at the project site once heavy rainfall occurs on the Raccoon River basin.

This information on stage levels on the Raccoon River is readily accessible to the locals through the ALERT system. Plus, severe weather alerts are issued by the NWS and relayed to the proper public emergency service offices. Both Des Moines and West Des Moines have standard operating procedures to monitor Raccoon River flooding. The city of Des Moines currently has one completed and one on-going downstream local flood protection project on the Raccoon River which include the monitoring of Raccoon River stages.

Walnut Creek:

The need for advance flood warning information on the Walnut Creek basin was highlighted by the May 1986 flood event. This flood-of-record event was produced be an intense convective storm centered over the upper basin. The precipitation activity occurred mainly during a 3 hour time period from 7 to 9 p.m. of the evening of May 9th. Spot rainfall depths of up to 6.9 inches were documented after the storm. Average rainfall on the upper basin was in the 4-5 inch range. The lower portions of the basin received only moderate rainfall of generally less than 1 inch.

Shortly after 9 p.m., the NWS office at the Des Moines Airport issued a Flash Flood Warning for Walnut Creek based on weather radar readings for the area. The depths of actual rainfall were unknown at the time. Five hours later at 2 a.m. of May 10th, Walnut Creek exceeded flood stage downstream at the 63rd Street stream gage and peaked 2 hours later at 4 a.m. The cities located along Walnut Creek responded to the impending flood based on observations of flood levels of the creek within their jurisdictions. In most cases, this proved to be to late for any advance flood fighting or evacuation measures.

City officials in the metropolitan area of Des Moines realized that measures must be undertaken to improve the flood warning capabilities on the Walnut Creek basin. The end result was the Des Moines ALERT system. The ALERT system was viewed as an interim non-structural flood damage reduction measure the locals could undertake pending construction of the proposed Raccoon River and Walnut Creek federal flood protection project by the Corps of Engineers. This federal project was reactivated by the 1986 Water Resources Act. Upon completion of the flood protection project, the cities of Des Moines and West Des Moines would be able to utilize rainfall and forecasted crest information generated by the NWS and the ALERT system to determine which roadway/railroad levee closures, storm sewer gatewells and valves would need closure, and other actions for

the proper operation of the overall project. Therefore, the Corps of Engineers was involved in the preliminary formulation of the flood warning system to ensure future functional capabilities and compatibility.

The Walnut Creek portion of the ALERT system includes four remote rainfall gages and three stream gages. The gage locations are shown on plate A-3. It is judged this network along with NWS weather information provides adequate data for hydrologic evaluations. These gages report to an automated data receiver and minicomputer communication center at the NWS office in Des Moines.

This center can be interrogated at any time by the NWS or the locals to obtain needed data. As a system enhancement, each gage has a threshold parameter which sets off an alarm warning. The threshold for the precipitation gages is 2.0 inches in any 6 hour or less time period. A rate of rise exceeding 1 foot per 1 hour after reaching a pre-determined level will trigger the stream gage alarm warning. The local NWS office in conjunction with the NWS River Forecast Center (RFC) in St. Paul judged these thresholds to be levels at which Walnut Creek flooding could potentially be threatening. When these thresholds are met, the NWS will contact each city with an official notice of alert. From this point, the cities will access and monitor the ALERT system to keep abreast of developing conditions.

The RFC has also developed Flood Advisory Tables for the three stream gages tied into the Walnut Creek portion of the ALERT system. These three tables are included as Attachment C. These tables provide rapid peak stage forecasts using antecedent moisture indexes produced by the Antecedent Precipitation Index (API) method. The forecasting relies on the Flood Advisory Tables of pre-computed flood stages for various antecedent conditions and average basin rainfall amounts. The attached Flood Advisory Table for the 63rd Street gage location reflects project conditions as the levee construction impacts on the existing gage rating curve. This technique has been provided to numerous NWS field offices and communities needing a method to produce an estimated flood peak. The tables also forecast the timing of the rate of rise to flood stage and time of peak. The RFC provides daily values of the Basin Index rainfall, reflecting the current antecedent moisture conditions. The locals can then access Walnut Creek rainfalls, enter the Flood Advisory Table with the Basin Index, and determine a flood peak estimate. The NWS currently provides this service as part of their flood warning responsibilities, and will continue to do so. A copy of the Flood Warning bulletin for March 13, 1990 is included as Attachment D.

The above mentioned API method is a running daily index that reflects the current moisture level of the area. The API is increased by precipitation and decreased by a seasonally dependent factor. The API for a given day is then used in the

basin's rainfall-runoff relationships along with the time of year, the rainfall depth, and the storm duration. The resulting storm runoff is then applied to the appropriate unit hydrograph watershed model for the basin to generate the basin's runoff hydrograph. A copy of the Des Moines Hydrologic Service Area daily basin index for March 14, 1990 is included in Attachment E. Note the listing includes the 3 Walnut Creek stream gages used in the Des Moines ALERT system and 4 Raccoon River basin locations. The watershed modelling done by the RFC has been coordinated with the Corps of Engineers and additional HEC-1 modelling has verified the RFC methods.

The NWS, as part of the development of the Flood Advisory Tables, determined bankfull, alarm, and flood stages for the three stream gages. The two upstream gages are new locations, whereas, the downstream 63rd Street gage has been in existence since October 1971. The various stages along with other pertinent information is listed in Table A-A.

TABLE A-A

Stream Gage Data For The Des Moines ALERT System

Location	Sensor Number	Gage Datum (NGVD)	Bankfull Stage	Flood Stage	Alarm Stage
Waukee 3NE	1013	897.00	7	9	7
I-35/80	1003	850.00	7	11	9
63rd Street	1051	801.04	11	13	-

The flood stage of 13 feet at the 63rd Street gage is consistent with what has been used in the past. The locals are familiar with this 13 foot stage and currently use it as a trigger point in flood fighting actions. It will continue as the trigger forecasted stage at which the initial operations of the proposed flood protection project will need to be initiated.

During a 100-year design storm, the ALERT system will give the locals 2-3 hours of advance warning time to make storm sewer gatewell closures at this 13 foot flood stage. The first roadway/railroad closure will have an advance warning time of 4 hours. Each successively higher closure will have increasingly longer advance warning times. These warning times are based on actual reported rainfall depths and pre-determined Walnut Creek watershed response. Thus, the warnings should be a reliable indication of a impending flood. False warnings should be minimized based on this system. Up-front of these warning times is existing severe weather forecasting which will place the local's emergency services personnel on alert 3 hours prior to the above warning times.

Summary:

Historically, the cities of Des Moines and West Des Moines have had to deal with Raccoon River and Walnut Creek flooding. Some low-level flood protection facilities exist on the Raccoon River in the project area and other comprehensive systems are in-place downstream. Thus, flood warning and response concerning Raccoon River flooding is already in-place due to existing institutions. The operation procedures for the Raccoon River portion of the project will be incorporated into their existing flood emergency plans.

The flood warning and response on the Walnut Creek portion is more critical due to the flash flood nature of the stream. However, the locals have foreseen this and have installed an early weather warning system centered around the ALERT system and existing NWS severe weather forecasting. Forecasts of flooding based on anticipated rainfall will not typically be released to the public due to the inherent uncertainties. However, emergency personnel and resources can be mobilized and ready when it appears that a flood situation is likely to occur.

The ideal situation now exists, the locals have an operational flood warning system which they are intimately familiar with. This situation has occurred 2-4 years before the flood protection project is constructed and becomes operational. Most all of the warning system start up problems will have been resolved and institutional responses to the warning will have been established.

FLOOD RESPONSE

The Des Moines ALERT system provides the crucial advance flood warning. However, this information would be of minimal benefit without a flood response plan. The cities of Des Moines and West Des Moines fully realize this fact and are currently updating their flood response plans to include the addition of the ALERT system. Both locals currently have adopted flood response plans which detail objectives, responsibilities, emergency operation procedures, specific flood-fighting measures and closure elevations for existing facilities. Each city will be updating their respective plan to include the addition of the proposed local flood protection project for the Raccoon River and Walnut Creek. The following will summarize their adopted plans.

Des Moines:

The city of Des Moines currently has a Flood Emergency Plan (Reference T) published by their Public Works Department. The plan outlines an operating procedure and the general duties and responsibilities of the Public Works and Engineering Departments when responding to a flood emergency. The Chief Administrator of all emergency operations is the City Manager or his designated

representative. The Director of Operations is the Public Works Director or his designee, and he is directly responsible to the City Manager for coordinating the entire emergency program with all other city departments and outside agencies.

The Flood Emergency Plan states that a Control Center shall be at the Public Works Central Maintenance Center located at 216 SE 5th Street. It should be staffed and operated around the clock in 8-hour or 12-hour shifts. The Control Center will have four telephone lines for receiving emergency calls, as well as outside lines for other communications. All calls regarding the emergency operation should be channeled through the Control Center, reviewed and relayed to the proper authority for action. A form should be supplied for receiving all incoming information. These forms should be filled out by telephone operators and turned over to the administrator for proper referral and action. Normal staffing of the Control Center should be personnel from the Public Works and Engineering Departments. This Control Center is where the Des Moines ALERT system has its 24-hour manned base station for the City of Des Moines.

The Public Works Department has planned for the following activities by division:

1. Sewer Maintenance Division
   a. Operate and install pumps
   b. Close flood gates on levee closures
   c. Assist in welling manholes
   d. Clear debris at culverts

2. Street Maintenance Division
   a. Deliver and place barricades
   b. Fill and place sandbags
   c. Construct earth closures
   d. Emergency levee repairs

3. Sidewalk Section
   a. Fill and place sandbags

4. Bridge Section
   a. Clear logs and debris buildup at bridges
   b. Aid in barricade placement
   c. Set up emergency generators and lighting

5. Street Cleaning Section
   a. Aid in hauling materials
   b. Fill and place sandbags

6. Radio Communications
   a. Maintain all communications systems.

Other general management duties of the Public Works Department include:

1. Staffing the Flood Control Center
2. Aiding Engineering Department in levee patrol
3. Aiding Engineering Department in record keeping
4. Analyzing weather and flood stage data.

The Engineering Department is responsible for performing the following emergency activities:

1. Analysis of Weather Bureau information including obtaining, analyzing, record keeping and monitoring of critical information such as expected crest, necessary height of sandbag or other closures, etc. Proper notification should be made to all affected railroads when closures are necessary across railroad lines.

2. Provide current up-to-date plans.

3. Levee patrol including staffing for all shifts of personnel necessary to patrol the levee system.

4. Record keeping and damage analysis including surveying of high water marks, flood limits and any technical reports of analyses of damage or potential damage to structures due to the flood.

The Flood Emergency Plan provides a listing of key city staff along with home and work telephone numbers. The plan also contains a location by location description, action, closure elevation and pertinent information on every storm sewer, sanitary sewer, levee closure, pump station, and street closure needed within the city which may be affected by river flooding.

The Flood Emergency Plan will be updated to include the specific information needed to operate the Des Moines phase of the proposed flood control project. Departmental responsibilities will remain the same. The updating will include a utilization plan for the ALERT system on Walnut Creek. The flash flood nature of Walnut Creek requires on-duty city personnel to implement the necessary closure operations of the project. This will include personnel from the police, fire and public works departments responding to the real-time data provided by the ALERT system. It is planned that alert and mobilization stages will be established once the NWS issues a Flash Flood Watch for the Walnut Creek basin. This typically occurs when meteorological conditions exist which could result in severe rainfall. Thus, appropriate personnel will have been placed on alert prior to the start of any severe storm and potential flood situation.

West Des Moines:

The city of West Des Moines currently has an adopted Flood Hazard Operational Plan (Reference U) developed by the Department of Civil Defense. The plan provides a list of guidelines for the organization, procedures, and resources necessary for public safety in the event of threatened or actual flooding. The objectives stated in the plan are threefold:

1. Provide early notification to affected persons of anticipated or pending flood hazards,

2. Institute preventive measures so far as possible,

3. Provide recuperative services as soon as possible following the event.

An Emergency Operations Staff is created for the purpose of working as a management team in generally controlling and supervising overall flood emergency actions. The Mayor, City Manager, Civil Defense Director, Police Chief, City Engineer, Public Works Superintendent, Waterworks General Manager, and Fire Chief comprise the personnel of said team. Basic responsibilities of the Emergency Operating Staff include sizing up the situation based upon reports from field units and other sources, determining the strategy and tactics that will be used in dealing with the flood emergency, and exercising direction and control over local forces.

The Flood Hazard Operational Plan outlines West Des Moines Departmental responsibilities to be as follows:

Building Department: Contact utilities for turning off services in flooded areas, institute and administer safety measures for the general public's well-being, and inspect structures within flood areas for potential hazard and insurance purposes.

Civil Defense: Establish Emergency Operating Center, establish field headquarters, and coordinate with other assisting agencies such as the Polk County Civil Defense, State of Iowa Civil Defense, Army Corps of Engineers, Red Cross, Salvation Army, National Guard, etal.

Engineer Department: Prepare and provide maps showing areas susceptible to flooding at various river stages, prepare and provide design and location of levee or other barrier structure construction, locate borrow areas and negotiate provisions for their use, supervise levee or other barrier structure construction utilizing city forces, private assistance and/or volunteer help, and maintain log and photographs of emergency flood operations.

Fire Department: Assist in alerting citizens, assist in rescue operations, provide mobile emergency radio center, locate and

assemble emergency lighting systems, and assist at field headquarters.

Park Department: Assist Public Works Department with personnel and equipment.

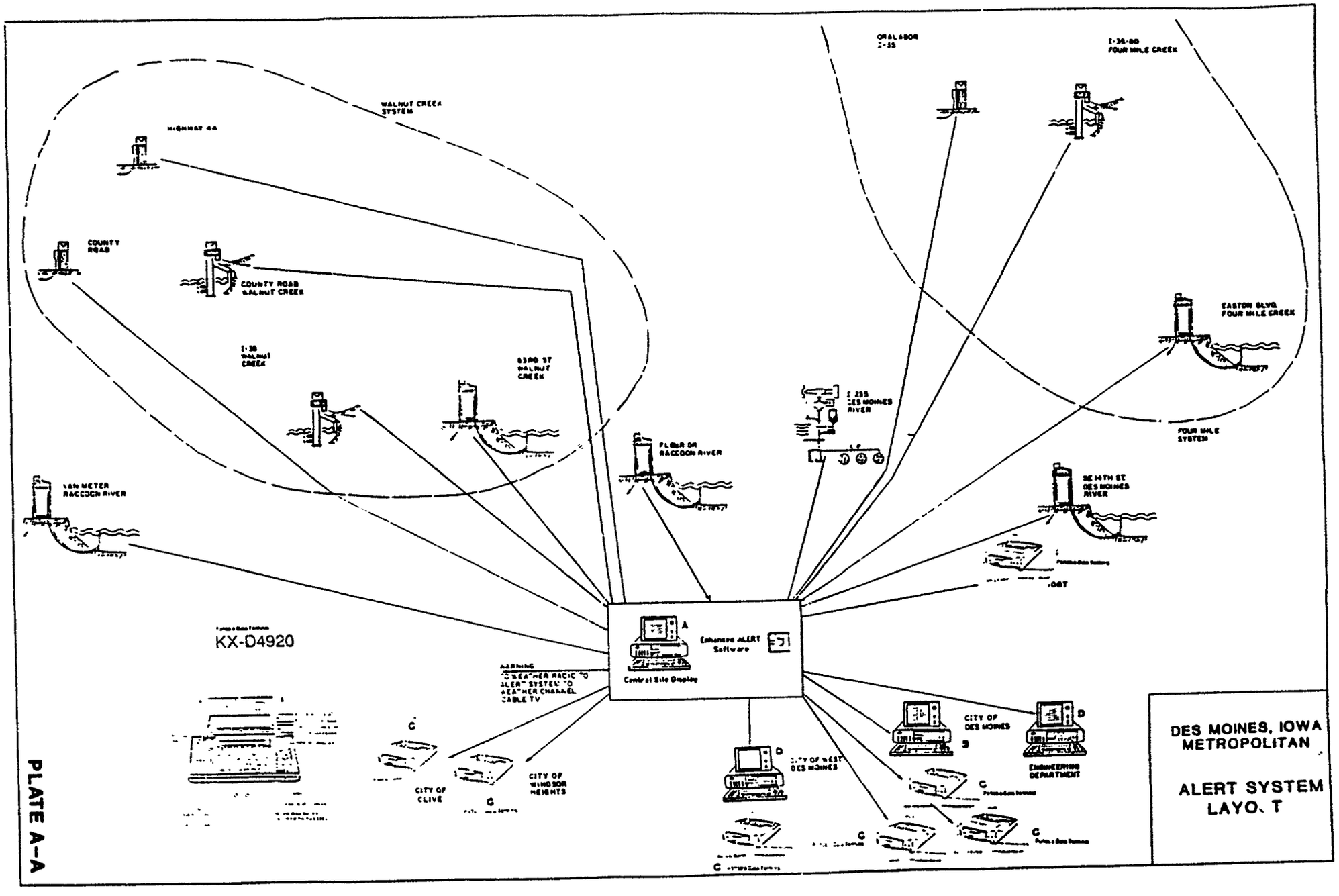
Police Department: Sign and barricade streets, establish and supervise all radio networks needed for emergency flood action, alert the Emergency Operations staff of impending flood levels, alert persons in flood hazard areas, evacuate residents and rescue trapped persons if necessary, control access to flooded areas, and maintain activity log of all events and actions.

Public Works Department: Prepare plans for storm and sanitary sewer closure and emergency pumping, obtain sandbags needed for flood control with predetermined sources available, control all sandbag supplies and sale of same to private citizens and businesses, establish sandbag filling sites, and maintain equipment list of pumps, trucks, hand tools, etc. that may be called upon for assistance in fighting floods.

Water Department: Protect water plant and wells from flooding, authorize basement flooding, and assist the Public Works Department with personnel and equipment.

The current plan has devised a three phase general operation to trigger actions based upon the likelihood of flooding. A color code of green-yellow-red is used and ranges from the least threat to the greatest. Procedures, which are triggered by observed or expectant stages on the Raccoon River or Walnut Creek, are specified to give direction in flood-fighting activities. The directions include stated levels at which to close existing storm sewer gatewells, when to initiate sand bagging, levee construction, and emergency pumping, and which streets should be barricaded.

The general operations section of the Flood Hazard Operational Plan will be updated to provide specific guidance on the operation of the proposed local flood protection project. General flood-fighting responsibilities will remain with the Engineering and Public Works Departments with real-time response to the Des Moines ALERT system being provided by the Police and Fire Departments on a backup basis. As with the Des Moines Flood Emergency Plan, it is anticipated that alert and mobilization stages will be established when the NWS issues a Flash Flood Watch for the Walnut Creek basin.


WALNUT CREEK SYSTEM
HIGHWAY 44
COUNTY ROAD
COUNTY ROAD WALNUT CREEK
I-35 WALNUT CREEK
63RD ST WALNUT CREEK
VAN METER RACCOON RIVER
FLOYD DR RACCOON RIVER
ORALABOR I-35
I-35-80 FOUR MILE CREEK
I 235 DES MOINES RIVER
EASTON BLVD FOUR MILE CREEK
FOUR MILE SYSTEM
SE 14TH ST DES MOINES RIVER
KX-D4920
Enhanced ALERT Software
Central Site Display
CITY OF CLIVE
CITY OF WINDSOR HEIGHTS
CITY OF WEST DES MOINES
CITY OF DES MOINES
ENGINEERING DEPARTMENT
PLATE A-A
DES MOINES, IOWA METROPOLITAN
ALERT SYSTEM LAYOUT

CITY OF DES MOINES, IOWA
MEMORANDUM OF UNDERSTANDING
FOR COMMUNITY SPONSORED
AUTOMATED FLOOD WARNING SYSTEM

This Memorandum of Understanding between the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) and the City of Des Moines a Municipal Corporation under the laws of the State of Iowa, hereinafter called "City" is undertaken for the purpose of defining a mutual assistance program designed to develop an Automated Flood Warning System for the Metropolitan Area of Des Moines, Iowa.

1. Authority

The NOAA National Weather Service undertakes this Memorandum of Understanding pursuant to its authority in 15 U.S.C. 313, 15 U.S.C. 1525, and 7 U.S.C. 450b, in order to carry out its functions relating to flood warnings.

2. Nature of Agreement

The Flood Warning Systm is being implemented in high risk flash flood areas. The system utilizes state of the art techniques that can be incorporated into an operational flood warning program. The overall concept calls for federal, state, county and municipal cooperation.

The National Weather Service and the City will cooperate to accomplish the installation and operation of an Automated Flood Warning System to help provide advance flood warning for the Metropolitan Area of Des Moines, Iowa, in accordance with this memorandum and the 28E Agreement herein attached and made a part of this memorandum.

3. Responsibilities of NOAA, National Weather Service

The National Weather Service shall:

a. Assist the City to identify the need for specific equipment for the warning system.

b. Assist community official in the site selection of hydrologic gages and consult with federal, state, local or private vendors on the need for calibration of hydrological models.

c. Provide training for county flood coordinators and municipal officials. The scope of the training shall cover:

1. NWS Flood/Flash Flood Watch/Warning Program,
2. Municipal Flood Warning Programs,
3. The need for emergency response planning, and
4. Periodic drills to test the program

ATTACHMENT A

e. Provide hydrometeorological forecast service for the area served by the flood warning system.

f. In conjunction with the Federal Emergency Management Agency, assure that the activites of the Automated Flood Warning System are coordinated with designated municipal, county, state and federal disaster officials.

g. Be responsible for obtaining Federal Communications Commission approval of the necessary radio equipment frequencies.

h. Assist in the site location of the field equipment and train the personnel in its operation.

i. Provide forecast advisory service for the selected river basins.

j. Provide system monitoring and consult with the community concerning forecast model recalibration needs, as required.

k. Operating the automated data receiver and minicomputer communication center at the National Weather Service Office.

l. Receiving and recording all reports of rainfall and flood conditions.

m. Serving as the official distribution point for all warnings and statements issued for the designated City.

4. Responsibilities of the City

The City shall:

a. Initially, pay for the capital cost of flood warning equipment and all installation costs with the exception of river staff gages and manual rain gages.

Long term, maintain system and pay for the capital cost of major equipment replacement upgrading, where necessary for the continued operation of the flood warning system.

The funding by the City of the operational and capital costs is conditional on the availability of appropriated funds within the City budgets.

Flood warning equipment may include any combination or all of the following.

1. Telemetered receiver, printers, and minicomputer systems,
2. Telemetered rain gages,
3. Radio repeaters for radio-telemetery,
4. Flash flood alarms, and
5. Telemetered river gages.
6. Software installation and model calibration.

b. 1. City operations center, including utilities and physical space.
2. Equipment used to support the City program, including telemetered river and rain gages, flash flood alarms, minicomputer systems, radio equipment, data receivers, repeater system, staff gages, and plastic rain gages.
3. Communications and utility costs to support the City activites.

c. Designate a City Flood Warning Coordinator by title to be trained in and responsible for the operation of a City preparedness plan.

d. Prepare a City preparedness plan to detail the necessary responsible actions to be taken, including coordination with the National Weather Service whever river and rainfall data indicate a possible need for statement and/or warnings. The plan will recognize that all flood warnings, including flash flood warnings, are to be initiated by the National Weather Service.

e. Establish a City Emergency Operating Center continuously, or as required for the purpose of:

1. Serving as the official distribution point for flood protection action statements and dissemination of resources.

2. Ensuring in addition to general public distribution, that flood warnings or statements reach warning action points as listed in the City preparedness plan.

3. Relaying river and railfall reports, flood data, and warnings to the National Weather Service Office in Des Moines as soon as soon as practiceable after local requirements have been satisfied.

5. Title to Equipment

Title to equipment purchased under this Memorandum of Understanding shall remain vested with the City.

6. Amendments or Modifications

This Memorandum of Understanding may be amended or modified by mutual agreement of the, National Weather Service and the City.

7. Termination

This Memorandum of Understanding may be terminated by either party upon sixty (60) days written notice to the other party, notice to begin with date of mailing.

a. Upon termination, all equipment listed by the National Weather Service as accountable shall be returned within sixty (60) days to the National Weather Service in the condition it was at the time of termination.

8. Effective Date

This Memorandum of Understanding is effective as of the last date shown below upon execution by both parties hereto.

Approved by:

NATIONAL WEATHER SERVICE

_____ _____
Signature - Iowa Area Manager Date

CITY OF DES MOINES, IOWA

By_____ _____
Mayor Date

FORM APPROVED:

_____ _____
City Solicitor Date
Infrastructure and Services

ATTEST:_____
City Clerk

AUTOMATED FLOOD WARNING SYSTEM FOR THE METROPOLITAN AREA OF DES MOINES, AGREEMENT

WHEREAS, the City of Des Moines is damaged yearly by flash flooding, and

WHEREAS, early Warning will help for reducing the damages from such flash floods, and

WHEREAS, the National Weather Service can assist in the implementation of an automated flood warning system that is capable of giving such early warning, and

WHEREAS, for the City to build such an automated warning system it is necessary for a Memorandum of Understanding to be a executed between the National Weather Service and the City a copy of said Memorandum of Understanding included in this agreement as Exhibit "A".

WHEREAS, such a system will initially service the City of Des Moines, City of West Des Moines, City of Clive, and the City of Windsor Heights; (with only those above executing this Agreement, hereinafter collectively identified as the Constituent Communities) and

WHEREAS, in order to construct, design, finance, build, operate and maintain said system, it is necessary to have an agreement between the Constituent Communities and

WHEREAS, the Constituent Communities are now desirous of such a system.

NOW, THEREFORE, it is agreed, by the Constituent Communities executing this Agreement, that an Automated Flood Warning System for the Metropolitan Area of Des Moines, Iowa, be designed, finanaced, built operated and maintained in the following manner set out herein, towit:

Section 1. The City Engineering Department of the City shall provide a design and cost estimate of the Automated Flood Warning System after consulting with a Committee of the Constituent Communities Engineers.

Section 2. The Constituent Communities shall approve to pay equal shares of that basic portion of the equipment and software to provide basic warning system for Walnut Creek. The City of Des Moines and the City of West Des Moines, shall divide the cost equally of adding the Van Meter gauging station, and that the City of Des Moines shall provide the cost of the rest of the system. That each Constituent Community pay for the receiving equipment used by them. The anticipated equipment list is included in this agreement as Exhibit "B". The estimated cost of equipment and estimated Constituent Community Cost participation is included in this Agreement as Exhibit "C".

Section 3. The City of Des Moines shall design and supervise the construction of the system by taking bids on the project after prerations of plans and specifications. The work shall be awarded to the lowest qualified bidder. In determining the lowest qualified bidder, the Committee of Constituent Communities City Engineer's shall be consulted.

Section 4. The City of Des Moines and the National Weather Service shall maintain the system in accordance with the Memorandum of Understanding included in this Agreement as Exhibit "A". The Constituent Communities shall be responsible for the maintenance of there own receiving equipment and there own phone lines. Each Constituent Community shall put into a maintaince fund initial amount equal to 10% of there construction contribution to be administered and held by the City of Des Moines. The Committee of Constituent Communities shall review the maintenance fund and determine if more money is needed for the fund on an annual basis and make recommendations on additions to the fund.

Section 5. COMPLIANCE WITH CODE OF IOWA, CHAPTER 28E. This Agreement is entered into in accordance with the provisions of Code of Iowa, Chapter 28E.

A. The duration of this Agreement shall be until July 1, 2000, subject to the provisions of paragraph 15 hereof.

B. This Agreement shall not be construed to create any separate legal or administrative entity.

C. This Agreement may be terminated by unanimous consent of the Constituent Communities or if the Memorandum of Agreement with the National Weather Service is terminated by them.

EARLY WARNING WEATHER ALERT SYSTEM

I. SCOPE

The Contractor shall furnish, install, and place into operation an Automated Local Evaluation in Real Time (ALERT) System. The Central Processing Unit shall be installed in the National Weather Service (NWS) office at the Des Moines International Airport. The data from a combination of water level/precipitation gauges as analyzed by the NWS shall be shared by various agencies in the Des Moines Metropolitan Area. The present goal for the system will be to provide the advanced flood warning with the provision for future expansion to provide warning for icing, snow, and other hazardous weather conditions.

II. GENERAL SYSTEMS REQUIREMENTS

2.1 Quality Assurance

The Alert System is an integrated system which is to be furnished complete and installed by one contractor. The system shall be coordinated with respect to the central processing unit, appurtenances, software, and VHF radio system with the manufacturers.

The Contractor shall be responsible for the satisfactory operation of the entire turnkey ALERT System.

The Contractor shall review specifications to determine if all equipment and software will work with their proposed equipment. If Contractor finds equipment and/or software incompatible, he shall submit in writing any such problems five (5) working days prior to the bid date for corrections or additions by the Project Engineer.

In order to establish a basis of quality for some items in the work, certain processes, types of machinery and equipment, or kind of material may be mentioned on the plans by designating a manufacturer by name and referring to his brand or model numbers. Such mention is not intended to exclude other processes, equipment or materials that will measure up to the designated standards of that mentioned. If the Contractor desires to use other products as equal thereto, he shall submit documentation showing a direct comparison of equipment as equal. Proposed equipment or software changes should be submitted five (5) working days prior to the bid date for approval.

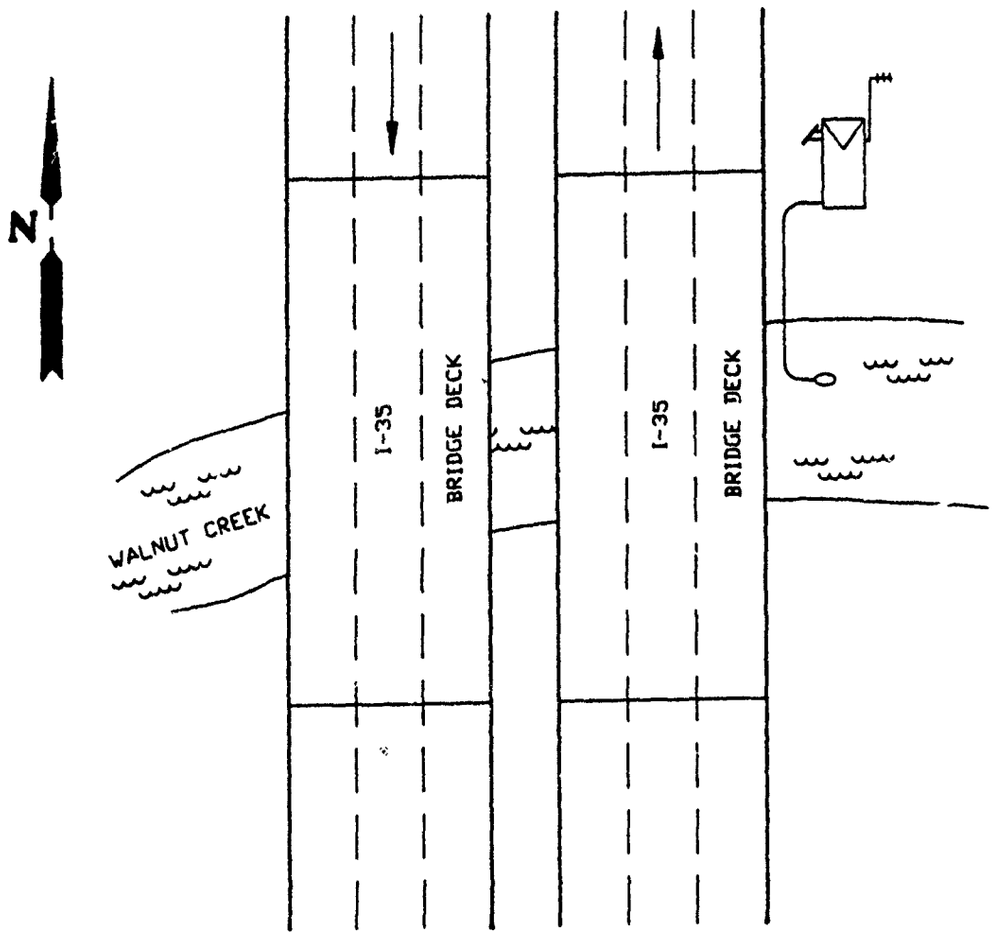
Wherever in the contract documents a manufacturer's name, brand or model is mentioned, it is to be understood that the phrase "or equal" is assumed to follow thereafter whether or not it does in fact.

2.2 System Overview

The system shall collect water level and rain data from the following locations in the Des Moines Metropolitan Area:

ATTACHMENT B

SITE #1 I-35/I-80 BRIDGE OVER WALNUT CREEK



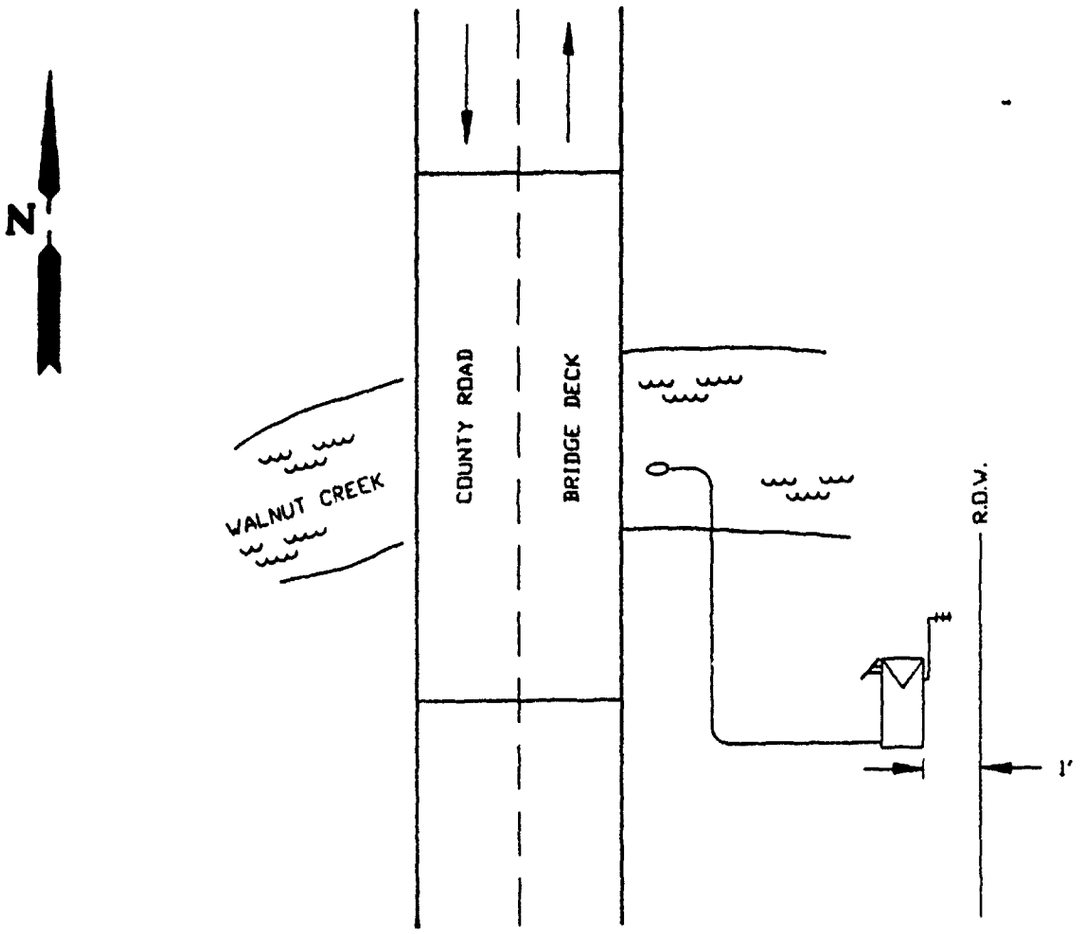
SITE #1 STIPULATIONS:

A. THE WATER LEVEL SENSOR CABLE WILL BE TRENCHED 24" BELOW GRADE.

B. SENSORS AT THIS SITE INCLUDE:
   1. 1 @ WATER LEVEL SENSOR
   2. 1 @ PRECIPITATION GAUGE SENSOR

ACT\DC-1

SITE #2 COUNTY ROAD OVER WALNUT CREEK



SITE #2 STIPULATIONS:

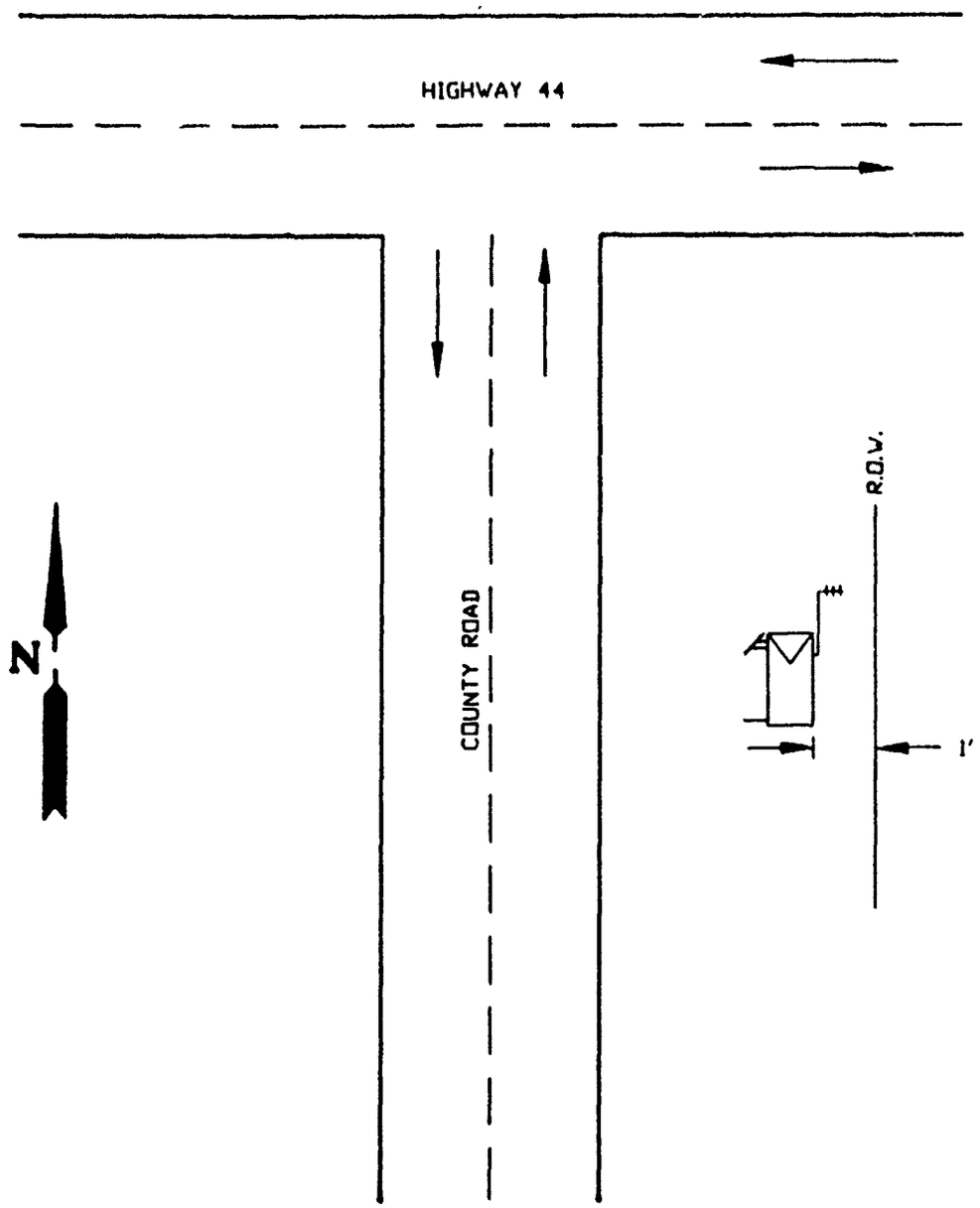
A. THE WATER LEVEL SENSOR CABLE WILL BE TRENCHED 24" BELOW GRADE.

B. SENSORS AT THIS SITE INCLUDE:
   1. 1 @ WATER LEVEL SENSOR
   2. 1 @ PRECIPITATION GAUGE SENSOR

C. WATER LEVEL/PRECIPITATION GAUGE SHALL BE LOCATED ONE FOOT FROM RIGHT-OF-WAY LINE ON COUNTY ROAD R.O.W.

ACT\DC-2

SITE #3 COUNTY ROAD



SITE #3 STIPULATIONS:

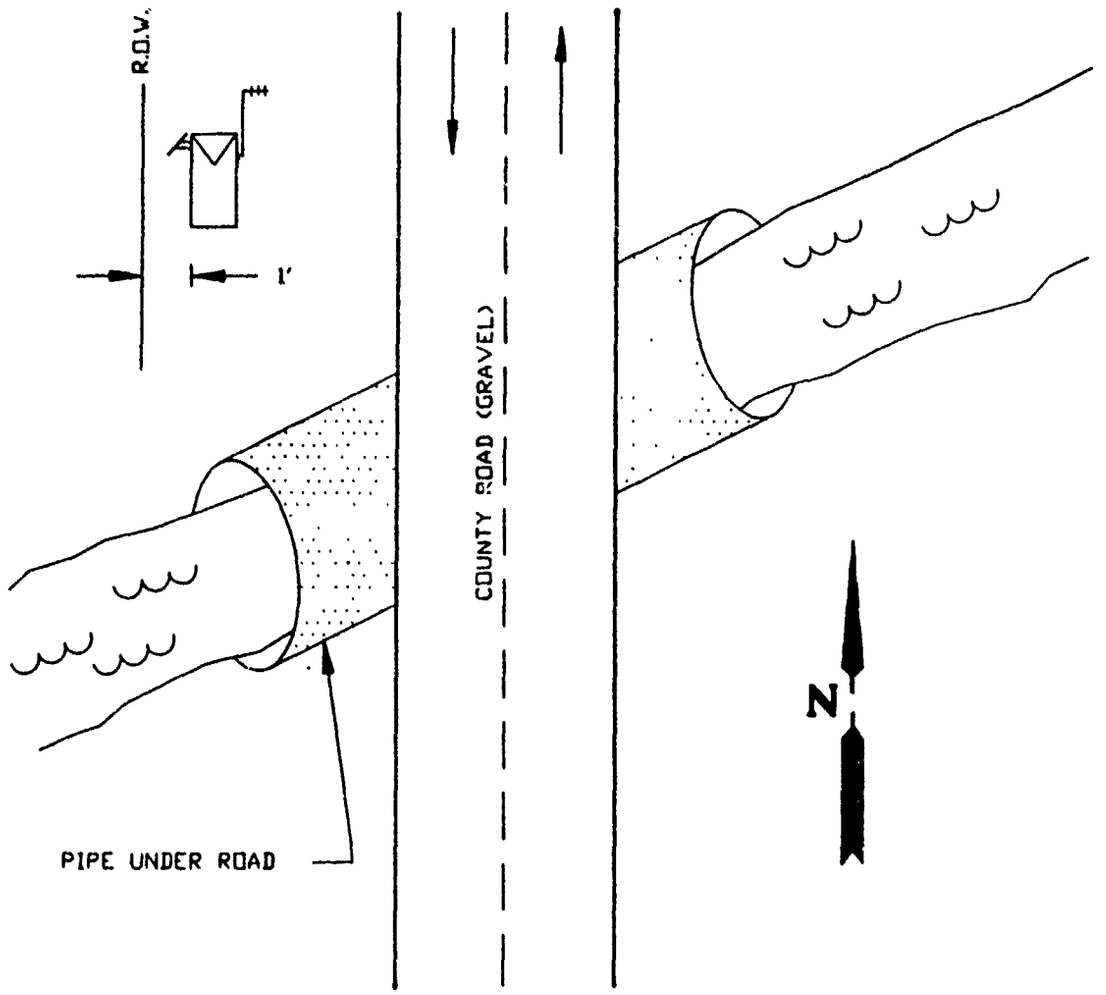
A. PRECIPITATION GAUGE SHALL BE LOCATED ONE FOOT FROM RIGHT-OF-WAY LINE ON COUNTY ROAD R.O.W.

B. SENSORS AT THIS SITE INCLUDE:
   1. 1 @ PRECIPITATION GAUGE SENSOR

ACT\DC-3

SITE #4 COUNTY ROAD

(WALNUT CREEK DRAINAGE BASIN)



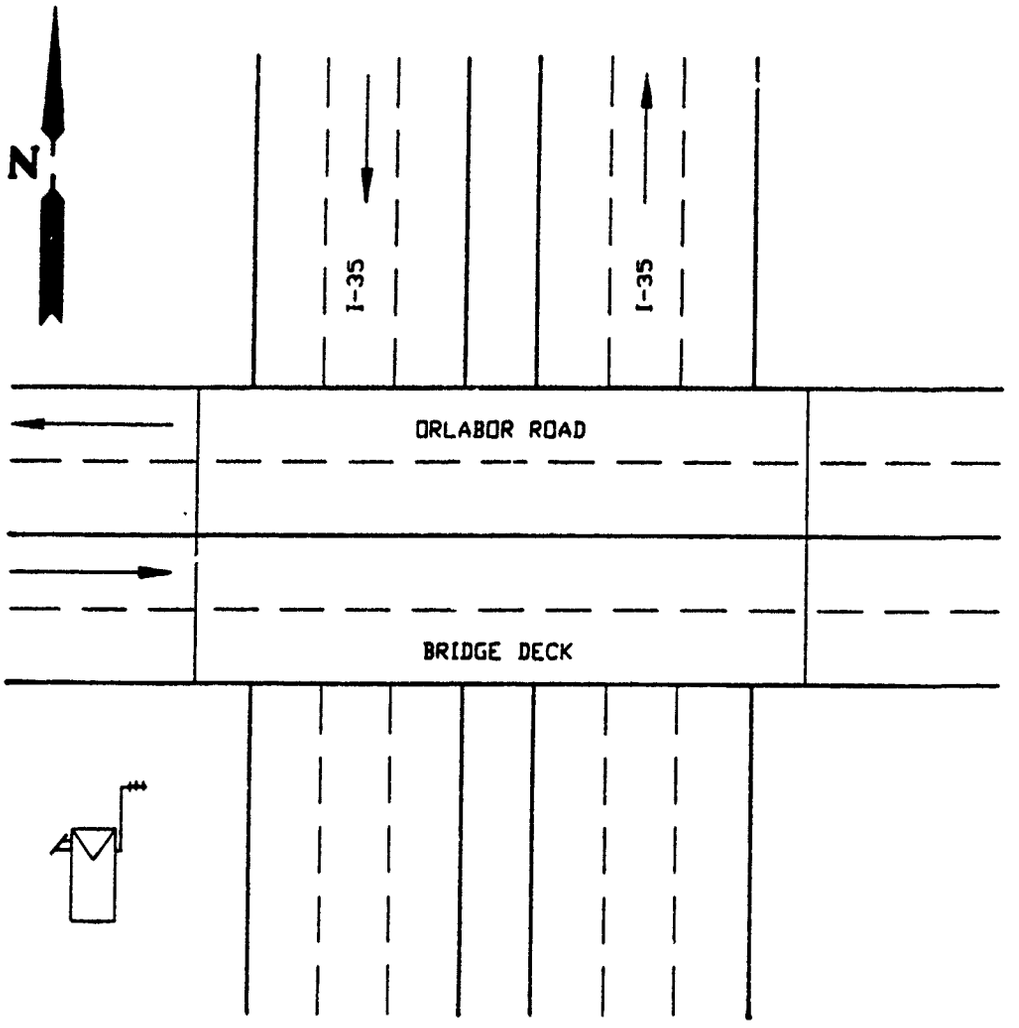
SITE #4 STIPULATIONS:

A. PRECIPITATION GAUGE SHALL BE LOCATED ONE FOOT FROM RIGHT-OF-WAY LINE ON COUNTY ROAD R.O.W.

B. SENSORS AT THIS SITE INCLUDE:
   1. 1 @ PRECIPITATION GAUGE SENSOR

SITE #5 I-35 and ORLABOR ROAD (ANKENY)

(FOUR MILE BASIN)

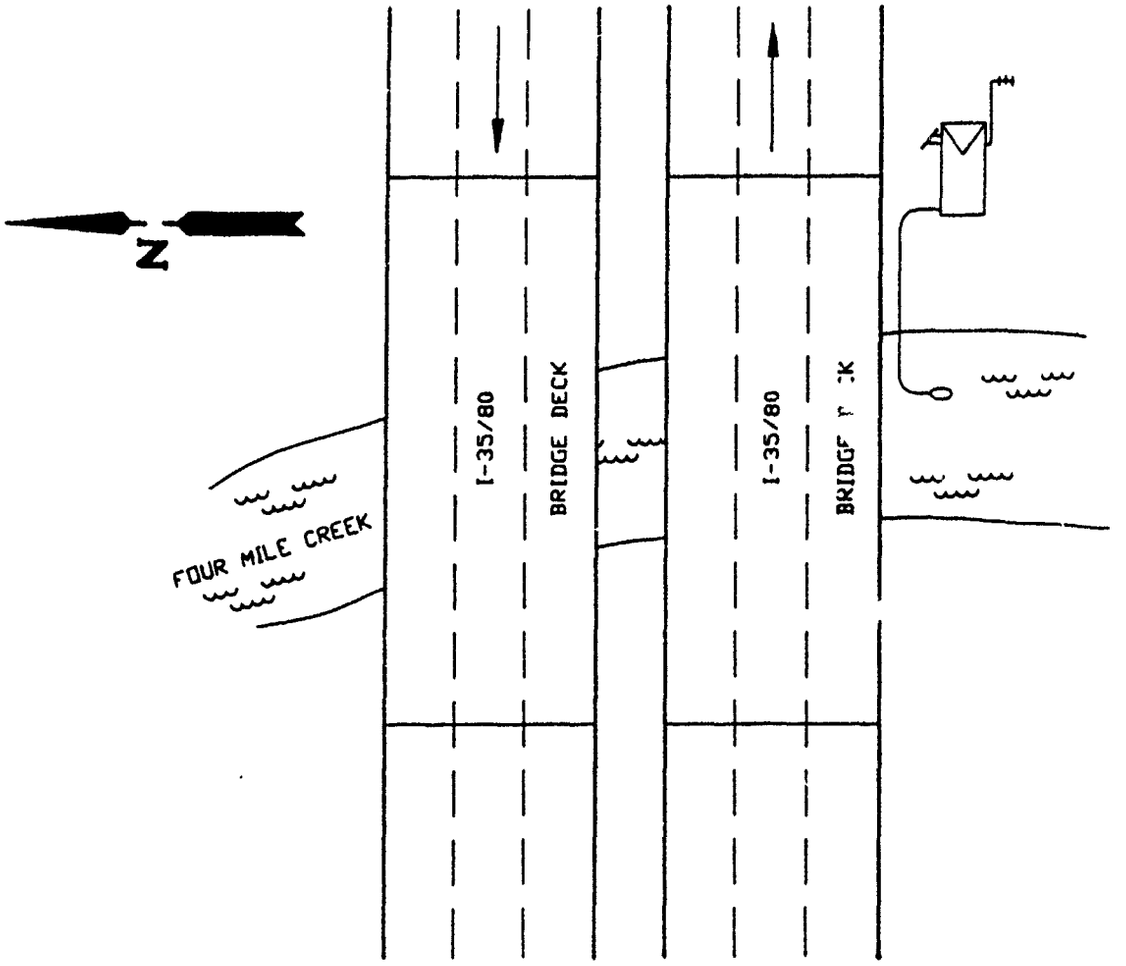


SITE #1 STIPULATIONS:

A. PRECIPITATION GAUGE WILL BE LOCATED IN STATE RIGHT-OF-WAY SUCH AS TO NOT CREATE A HAZARD TO TRAFFIC.

B. SENSORS AT THIS SITE INCLUDE:
   1. PRECIPITATION GAUGE SENSOR

SITE #6 I-30 AT FOUR MILE CREEK



SITE #1 STIPULATIONS:

A. THE WATER LEVEL SENSOR CABLE WILL BE TRENCHED 24" BELOW GRADE.

B. SENSORS AT THIS SITE INCLUDE:
   1. 1 @ WATER LEVEL SENSOR
   2. 1 @ PRECIPITATION GAUGE SENSOR

Sites:

1.	I-35/I-80 and Walnut Creek	Water Level/Precipitation Gauge
2.	County Line Road over Walnut Creek	Water Level/Precipitation Gauge
3.	County Road (South of Highway 44)	Precipitation Gauge
4.	County Road (Walnut Creek Drainage Basin)	Precipitation Gauge
5.	I-35 and Orlabor Road (Ankeny) Four-Mile Basin	Precipitation Gauge
6.	I-80 at Four-Mile Creek	Water Level/Precipitation Gauge
7.	S.E. 14th and Des Moines River	Incremental Shaft Encoder and Hydrologger™

The appropriate sensors shall be capable of measuring water levels and rainfall rates. The sensors shall be connected to the Data Collection Unit which will measure all sensory output, analyze the data, and initiate a data transmission to the Base Station if preprogrammed parameters are met.

All new installations shall transmit field data via line-of-sight VHF radio transmitters on a proposed frequency of 171.900 MHz to the Base Station. The Base Station (Central Computer) shall collect, process, and store data from all Data Collection Units to be displayed for analysis. The Display Equipment shall be connected to the Central Computer to display data collected from the Data Collection Units and also be able to access the National Weather Service (NWS) "LARC" System and display data from this system.

2.3 System Communication

Communication from the Data Collection Units to the Base Station shall be via VHF radio on proposed frequency of 171.900 MHz. The Base Station shall consist of an omni antenna, receiver, decoder, central computer with keyboard, display, and printer, plus all associated electrical wiring, cabling, and hardware.

2.4 Data Distribution

The collected and processed data contained in the Central Computer shall be available for display by various agencies in the Des Moines Metropolitan Area. The Main Display and Central Computer shall be located at the Des Moines International Airport. The Central Computer and Main Display will be controlled by the National Weather Service (NWS) to forecast flooding. Secondary displays and controls shall be located at:

The City of Des Moines Public Works Department
The City of Des Moines Engineering Department
The City of West Des Moines

Access to the data in the Central Computer shall also be available to:

The City of Clive

Other cities or agencies as may be necessary.

The Computer located at the City of Des Moines Public Works Department--E.O.C. (Emergency Operating Center) shall be capable of backing up all data received at the Base Station. The computer located at the Base Station and the E.O.C. shall also have the capability to communicate with two (2) other stations at the same time including, but not limited to, the portable data terminals as specified in Section 5.2.

2.5 System Expansion

The design of the system shall permit the adding of Data Collection Units for both water level/precipitation and pavement/atmosphere conditions. The addition of Data Collection Units shall require a minimum of additional hardware and software at the Base Station.

III. DATA COLLECTION EQUIPMENT

The Data Collection Equipment shall consist of:

Sensors
Data Collection Units
Communications Equipment

3.1 Precipitation Gauge Sensor Enclosure and Supporting Structure

3.1.1 Precipitation Gauge Sensor shall be enclosed in a supporting structure which shall consist of a noncorrosive cylinder, a minimum of 18 feet above existing ground surface and a minimum of 12 inches in diameter. The amount of bury of the cylinder shall be determined by the contractor based on wind load, soil conditions, and amount of concrete used for the base. The proposed installation shall be reviewed by the Project Engineer prior to installation. The precipitation gauge shall sit on top of the vertically installed cylinder in its own enclosure.

3.1.2 Concrete used for the base of the supporting structure shall be a standard 4,000 lbs. commercial mix.

3.1.3 All electronic equipment shall be placed below ground level in the bottom of the cylinder. No ground level doors, openings, or wires shall be provided in order to minimize vandalism. Inside the supporting cylinder, provisions shall be made for a nylon rope attached

to the electronics package for use in removing it from the bottom of the structure. Adequate room shall also be provided for all connecting cables and transmitting lines which enter the bottoms or tops of the cylinder when removing the electronics package.

3.2 Precipitation Gauge Sensors

The Precipitation Gauge Sensors shall be the tipping bucket sensors enclosed in a straight-sided cylinder and 12 inches in diameter at the orifice. The tipping bucket shall be calibrated at a rainfall rate of 4 inches/hour.

3.2.2 The tipping mechanism shall have noncorrosive bearings which require full throw and alternating tips for signal transmissions. The tipping bucket mechanism shall measure one millimeter increments and be so constructed to prevent damage when water freezes in the bucket. Magnetic switching on the tipping bucket is required. Adjusting screws to calibrate the bucket and a self-contained level bubble and adjustments for proper leveling of the tipping bucket inside its enclosure shall be required. Tight-fitting, noncorrosive screens shall be included in the funnel to provide protection from debris from entering the mechanism.

3.2.3 Discharge vents shall be included to maintain dryness. Vents shall be screened to prevent insect entry. The base of the tipping bucket housing shall provide a waterproof seal. A vent tube between the supporting tower and the tipping bucket housing shall be included. The tube vent shall be placed to prevent drainage of water into the supporting structure.

3.2.4 A factory supplied metal covering shall be furnished to cover the rain gauge orifice during freezing weather. The covering shall be waterproof.

3.3 Water Level Sensors

3.3.1 The Water Level Sensors utilized in the system shall be of the latest technology pressure transducers. The sensors shall be capable of measuring the total range of water levels at each remote site. The range of water levels shall be 0-15 feet with the minimum accuracy of 0.1 foot throughout the entire range of readings.

3.3.2 The transducer to measure the stream flows shall be anchored by an approved means which shall provide a minimum of maintenance. Contractor shall submit detailed plan for anchorage prior to installation.

3.3.3 The cable between the transducers and the data transmitter shall not be spliced. The cable shall be direct-buried to a minimum depth of 24 inches and enter the bottom of the precipitation gauge sensor supporting structure through a waterproof conduit.

After inspection of the completed trench and cables, the Contractor hall backfill the trench with the material that was removed, unless

otherwise directed by the Engineer. Backfill material shall be placed in layers not exceeding one foot of loose thickness. Each layer shall be compacted by hand or mechanical tampers. Material containing glass, metal, concrete, brick, cinders, or any other abrasive material shall not be used for backfill within six inches of the cable or conduit.

Restoration shall include appropriate smoothing to its original condition and seeding of the area.

3.3.4 Should the contractor elect to use the bridge to run the cable on--the completed duct system shall be watertight. Expansion fittings shall be used where duct runs cross structural expansion joints and elsewhere as directed by the Engineer.

Contractor shall also have approval by the Iowa Department of Transportation and/or Dallas County Engineer prior to any installation involving a state or county bridge. Detailed plans for each bridge site may be reviewed at the City of Des Moines Engineering Office, Iowa Department of Transportation Maintenance Office, or Dallas County Engineering Office.

Metal conduit shall be threaded. The mating threads shall be treated with pipe-joint compound. All other threads shall be treated with an approved rustproofing compound.

After the duct runs are installed, the Contractor shall demonstrate that the runs are clear by pulling an approved brush or conduit swab through the entire length of each run. No deleterious material shall be permitted to remain in the duct.

All ducts for exposed installation shall be rigid steel conduit. When not shown on the plans, exposed ducts shall be supported at intervals of 6 feet or less. Hangers or clamps to be attached to concrete structures shall be anchored by means of expanding anchors in drilled holes. The use of driven or explosive-set anchors will not be permitted.

3.4 Data Transmitter

3.4.1 The Data Transmitter shall be completely enclosed in a water-tight, noncorrosive container and placed at the bottom of the supporting structure below ground level. It will include all the electronics, including the VHF radio transmitter, and the rechargeable batteries.

3.4.2 The Data Transmitter will be of such a size as to easily fit inside the cylinder and be below ground level. A handle will be included for attaching a nylon rope for removing and carrying the unit. Connectors at the top of the unit will be provided for interface to sensors, an antenna, and a solar panel assembly for charging the battery. All connectors shall be waterproof.

3.4.3 The Data Transmitter shall be compatible to sense contact closures from a tipping bucket sensor or an automated total precipitation

gauge. It shall also have the capability of collecting data from a submersible pressure transducer used to measure stream depths. The transmitter shall have provisions to expand the unit with up to 16 analog inputs for use with weather and other analog sensors.

3.4.4 The Data Transmitter will collect data from the tipping bucket by incrementing an accumulator. After initial calibration, the Base Station will determine the actual precipitation value from the known value of precipitation from each 1 mm tip or from a predetermined weight which registers as a count or tip. Other accumulators shall be able to decrement as well as increment counts for use with shaft encoders, pressure transducers or other sensors which have similar changes in sensing of events. All digital sensors shall transmit their ID codes and accumulator values immediately after a preselected parameter is met ("event mode") or at preselected timed intervals.

3.4.5 The Data Transmitter will have a means to set the ID code for the primary event sensor--rainfall. ID range shall be from 0 to 99 for ASC II format and 100 to 8191 for binary format. Digital event sensors will be automatically identified by substracting integers starting from the priority event and analog sensors will be automatically identified by adding integers starting from the priority event sensor.

3.4.6 To verify proper operations of a remote site a transmission shall occur at a minimum of every 12 hours for all sensors.

3.4.7 Radio:

3.4.7.1 The radio transmitter shall be capable of selecting by hardware switches, a synthesized VHF channel in the range of 165 to 174 MHz in 25 kHz increments. Radio shall be set for 171.900 unless directed otherwise by Project Engineer.

3.4.7.2 Minimum output shall be at least 8 watts at VHF.

3.4.7.3 In case of hardware failure, the transmitter will automatically be shut off after a reasonable time to prevent frequency jamming.

3.4.7.4 Transmissions during rapidly changing conditions will be constrained such that not less than 15 seconds will elapse between transmissions from a single transmitter.

3.4.7.5 Radio frequency stability will be controlled to a stability of 0.0005% from -30°C to +60°C.

3.4.7.6 Minimum Inputs: 4 digital and 16 analog.

3.4.8 Battery Operation:

3.4.8.1 The battery shall be a rechargeable Gel Cell with provisions for recharging from a solar panel or an AC charger. The battery shall be sized to provide optimum power to furnished equipment. The minimum-sized battery shall be 8 amp/hour.

3.4.9 Solar Panel:

3.4.9.1 Each remote site shall be provided with a solar panel for maintaining battery charge. The panels shall come with blocking diodes and regulator circuits designed to allow effective charging of gel battery without overcharging or discharging

3.4.9.2 Panels shall come complete with all mounting brackets and connecting cables.

3.5 Antenna

3.5.1 The antenna for remote sites shall be high-gain direction antennas constructed of high-strength aluminum alloys. All antennas shall be designed to survive 100 mph winds. No part of the antenna shall extend over the tipping bucket orifice.

3.5.2 The antenna will be mounted on a mast attached to the side of the supporting structure.

3.5.3 The antennas shall be in balance with the transmitting radio and have a minimum 7db of gain.

IV. BASE STATION EQUIPMENT

The Base Station Equipment shall consist of:

Communications Equipment

Personal Computer for the Display of Data

4. Base Station

4.1 The Base Station shall consist of the following primary components:

4.1.1 An antenna, receiver, decoder, and associated cabling to receive and decode data transmissions directly from remote collection sites.

4.1.2 A computer with keyboard, display monitor, and printer along with software that will collect, process, display, and store the received data.

4.2 Receiver

4.2.1 The receiver will be a single-channel receiver operating over the frequency range from 165 to 174 MHz for VHF. Minimum channel spacing shall be 25 kHz. Frequency stability shall be 0.001% or better. The instrument shall be operated with commercial AC voltage through the UPS.

4.2.2 The receiver shall be a single self-contained unit independent of the decoder but located with the decoder at the computer.

4.3 Decoder

4.3.1 The decoder shall be capable of decoding the signal from the receiver and inputing RS232C data into the computer. The decoder shall be operated with commercial AC voltage supplied through the UPS.

4.3.2 The decoder shall be a single self-contained unit independent of the receiver.

4.3.3 All connecting cable and hardware will be furnished to connect decoder to receiver.

4.4 Antenna

4.4.1 The Base Station antenna shall be an omni-directional antenna with a minimum gain of 6db. It will be constructed of a high-strength aluminum alloy and designed to survive a 100 mph wind.

4.4.2 The antenna shall be mounted in a quality workmanship manner to the cab of the abandoned control tower at the airport. All hardware shielded cabling shall be provided to mount the antenna and connect it to the receiver.

4.4.3 The antenna shall be provided with lighting protection.

4.5 Computer

4.5.1 The Base Station Computer shall be a Compac Deskpro 286 (Model 40) IBM/IBM compatible equivalent model with a 40 megabyte hard disk and capable of running continually.

4.5.2 Additional options to basic unit will be supplied by the computer manufacturer unless items are not available.

4.5.2.1 14" VGA Color Display and supporting board for the computer.

4.5.2.2 8-MHz 80287 Co-Processor.

4.5.2.3 Expansion board to expand ram memory to 2 megabyte plus memory chips.

4.5.2.4 Two (2) external 2400 bps phone modems (Hayes).

4.5.2.5 Four port serial multiplexer.

4.5.2.6 One (1) Okidata 391 24 pin printer and 2 ribbons.

4.6 Base Station Software

4.6.1 The software shall include the latest version of PC DOS at the time the equipment is delivered to the Base Station.

4.6.2 The QNX Multi-Tasking Operating System shall also be furnished.

4.6.3 Q-DOS Software plus all applicable manuals and disks.

4.6.4 Communication software will be supplied which is recommended and used by the phone modems supplied under Section 4.5.2.5.

4.6.5 Enhanced ALERT Environmental Data Collection Display and Analysis System (Sierra-Misco, Inc.--5073 RFO-API) which includes Automated Headwater Tables will be supplied which is approved by the National Weather Service and is the latest version available at the time of equipment delivery. It shall include all applicable manuals, disks and support VGA and EGA.

V. ADDITIONAL EQUIPMENT AND SOFTWARE

The additional equipment and software will be required for the following Cities:

City of Des Moines

City of West Des Moines

City of Clive

5.1 City of Des Moines

5.1.1 Computer

5.1.1.1 The City of Des Moines Public Works Department will be supplied one Compac Deskpro 286 Model 40 or IBM/IBM compatible equivalent model.

5.1.1.2 Additional options to the basic unit will be supplied by the computer manufacturer unless items are not available. All optional equipment shall be compatible and include all necessary cables, hardware and/or software to make it part of a functional system.

5.1.1.2.1 14" VGA Color Display and supporting board for the computer.

5.1.1.2.2 8-MHz 80287 Co-Processor.

5.1.1.2.3 Expansion board to expand RAM memory to 2 megabyte plus memory chips.

5.1.1.2.4 Two (2) external 2400 bps phone modems (Hayes).

5.1.1.2.5 Four port serial multiplexer.

5.1.1.2.6 One (1) Okidata 393C 120/450 printer and 2 color ribbons.

5.1.2 Portable Data Terminal

5.1.2.1 Contractor shall furnish three (3) Panasonic Portable Data Terminal (KX-D4920) which shall come with built-in acoustical couplers and printers. Two rolls of paper shall be supplied with each unit.

5.1.3 LARC Equipment

Contractor shall install a Hydrologger™ and incremental shaft encoder at the river gauging station at S.E. 14th and the Des Moines River and connect it to existing phone line.

5.1.3.1 One (1) Handar Model 550A Hydrologger™.

5.1.3.2 One (1) Handar Model 550-7001 Speech Synthesizer Modem Board.

5.1.3.3 One (1) Handar Model 436A Incremental Shaft Encoder.

5.1.3.4 Contactor will supply all necessary pulleys, gears, and tapes to slave new equipment to existing equipment.

5.1.3.5 National Weather Service Personnel will program Hydrologger™ after installation.

5.1.4 Software

5.1.4.1 One (1) copy of the latest version of PC DOS at the time the equipment is delivered to the City of Des Moines Public Works Department which comes with the computer specified in Section 5.1.1. or Bid Alternate Number 4.

5.1.4.2 One (1) copy of the latest version of QNX Multi-Tasking Operating System shall be furnished with all applicable manuals and disks.

5.1.4.3 One (1) copy of the latest version of Q-DOS plus all applicable manuals and disks.

5.1.4.4 One (1) copy of the latest version of Enhanced ALERT Environmental Data Collection Display and Analysis System (Sierra-Misco, Inc.--5073E) plus all applicable manuals and disks. The software shall also be able to support VGA and EGA.

5.1.4.5 One (1) copy of the latest version of Microsoft Excel Software plus all applicable manuals and disks.

5.2 City of West Des Moines

5.2.1 Phone Modem

5.2.1.1 One (1) external 2400 bps Hayes Smart Modem Model 07-00056.

5.2.2 Software

5.2.2.1 One (1) copy of the latest version of the Remote Computer Graphics Program (Sierra-Misco, Inc.--5073 REM) (DOS version) which is compatible with Section 4.6.5.

5.3 City of Clive

5.3.1 Portable Data Terminal

5.3.1.1 Contractor shall furnish one (1) Panasonic Portable Data Terminal (KX-D4920) which shall come with built-in acoustical couplers and printer. Two rolls of paper shall be furnished.

5.4 Shared Portable Data Terminal

5.4.1 Contractor shall furnish one (1) spare Panasonic Portable Data Terminal (KX-D4920) which shall come with built-in acoustical couplers and printer. Two rolls of paper shall be furnished.

5.5 Bid Alternate No. 1

5.5.1 One (1) copy of the latest version of Auto CAD by Autodesk Inc. plus all applicable manuals and disks.

5.6 Bid Alternate No. 2

5.6.1 One (1) 24"x36" Digitizer Board (Tablet) (Calcom-9100 Series).

5.6.2 One (1) 16' button cursor for 24"x36" Tablet (Calcomp).

5.7 Bid Alternate No. 3

5.7.1 IBM AT Model 5170 Math Co-Processor.

5.7.1.1 Math co-processor shall run at speed of basic computer unit (Intel).

5.7.1.2 Contractor will be responsible for installation of new co-processor chip.

5.7.2 IBM AT Model 5170 software.

5.7.2.1 One (1) copy of the latest version of the Remote Computer Graphics Program (Sierra-Misco, Inc.--5073 REM) (DOS version) which is compatible with Section 4.6.5.

5.8 Bid Alternate No. 4

5.8.1 Additional cost to be added to Item 8. City of Des Moines necessary to substitute the following defined computer and equipment in lieu of that model and equipment described in Section 5.1.1 through 5.1.1.2.6.

5.8.1.1 The City of Des Moines Public Works Department will be supplied one Compac Deskpro 386/25 Model 300 or IBM/IBM compatible equivalent model.

5.8.1.2 Additional options to the basic unit will be supplied by the computer manufacturer unless items are not available. All optional equipment shall be compatible and include all necessary cables, hardware and/or software to make it part of a functional system.

5.8.1.3 14" VGA Color Display and supporting board for the computer.

5.8.1.4 Math co-processor to run at same speed as basic computer unit.

5.8.1.5 4-megabyte 32-bit System Memory Board (with 2-megabyte 32-bit memory installed).

5.8.1.6 135 megabyte tape backup unit plus 5 tapes.

5.8.1.7 Two (2) external 2400 bps phone modems (Hayes).

5.8.1.8 Four port serial multiplexer.

5.8.1.9 One (1) 3.5" 1.44 megabyte floppy drive.

5.8.1.10 One (1) computer mouse (Microsoft mouse plus Microsoft windows).

5.8.1.11 One (1) Okidata 393C 120/450 printer and 2 color ribbons.

VI. OPERATING AND MAINTENANCE DATA

6.1 The following information for each unit of equipment and system shall be furnished:

6.1.1 Description of units, systems and component parts.

6.1.2 Circuit Directories of Panelboards.

6.1.3 Operating Procedures.

6.1.4 Maintenance Procedures.

6.1.4.1 Routine operations.

6.1.4.2 Guide to "troubleshooting".

6.1.4.3 Disassembly, repair, and reassembly.

6.1.4.4 Alignment, adjusting, and checking.

6.1.4.5 Winter storage (define period).

6.1.5 A list of all parts for the equipment with each part identified by a functional names, the name of the manufacturer of the part, the manufacturer's part name, and a unique part number (normally the part manufacturer's alpha-numeric designation). Parts list also to include:

6.1.5.1 Items and quanitities recommended to be stocked as spare parts.

6.1.5.2 Assembly drawings.

6.1.5.3 Illustrations.

6.2 Include additional data when the need for such data becomes apparent during instruction of Owner's personnel.

6.3 Training:

6.3.1 Supplier shall conduct a one-day approved training program for the Owner's maintenance personnel.

6.3.2 Supplier may use equipment furnished under this Contract provided equipment is not damaged. Maintenance, repair, and/or replacement

of failed or damaged equipment used for training shall be completed at no additional cost to the owner.

6.3.3 Supplier shall demonstrate all test procedures, adjustment and calibration procedures, and troubleshooting procedures on equipment supplied on this Contract.

6.4 Warranty

6.4.1 Contractor shall supply a one-year warranty on all equipment, except for batteries, which shall be warranted for three months from date of acceptance.

6.5 Performance and Maintenance Bond

Due to the nature of the equipment and its proposed use, Section 7-2 of Division One--General Provisions and Covenants--shall be modified to read "within three (3) days,".

VII. BID REFERENCE ITEMS

7.1 Contractor will install base station receiver station prior to any installation of remote field units. All remote sites will be tested for radio transmissions prior to actual installation. If radio transmissions from remote sites are not of sufficient strength at the base station, contractor shall immediately notify project engineer.

7.2 All radio transmissions and receiver cables shall be shielded. Contractor shall take all necessary precautions not to cause interference with existing radio equipment located at the National Weather Service and Des Moines Aiport.

7.3 Contractor will be responsible for site restoration at each site.

7.4 Contractor shall familiarize himself with each site prior to bidding the project to determine necessary lengths of cable for each pressure transducer. Optimum lengths should be determined for each site for the proposed equipment to be furnished.

7.5 Contractors bid shall be balanced to reflect actual cost per each individual bid item.

WALNUT CR.-W. DES MOINES,DES MOINES,IA FLOOD ADVISORY TABLE

.....THIS TABLE IS DEVELOPED FOR THE LOCAL PROTECTION PROJECT...

FLOOD STAGE IS 13.0 FEET

LAG FROM BEGINNING OF THE TIME PERIOD OF HEAVIEST RAIN TO CREST IS 9 HOUR(S).

	STAGE FEET	DISCH. CFS	6 HOUR RAINFALL AMOUNTS (INCHES)									HRS FROM BGNG OF R/F TO FS
	10.0	1500	0.7	1.1	1.5	1.9	2.4	2.8	3.3	3.7	4.2	----
	11.0	1901	0.8	1.2	1.7	2.1	2.6	3.0	3.5	4.0	4.5	----
	12.0	2350	0.9	1.3	1.8	2.3	2.8	3.3	3.7	4.2	4.7	----
FS	13.0	2900	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	9
	14.0	3500	1.1	1.6	2.2	2.7	3.2	3.7	4.2	4.7	5.3	8
	15.0	4201	1.3	1.8	2.4	2.9	3.4	4.0	4.5	5.0	5.5	7
	16.0	5000	1.4	2.0	2.6	3.1	3.7	4.2	4.7	5.3	5.8	6
	17.0	5800	1.6	2.2	2.8	3.3	3.9	4.4	5.0	5.6	6.1	6
	18.0	7000	1.8	2.5	3.0	3.6	4.2	4.8	5.3	5.9	6.5	5
	19.0	9000	2.2	2.9	3.5	4.1	4.7	5.3	5.9	6.5	7.0	4
	20.0	12000	2.8	3.5	4.1	4.7	5.4	6.0	6.6	7.2	7.8	4
	21.0	15200	3.4	4.1	4.8	5.4	6.0	6.7	7.3	7.9	8.5	4
	22.0	19000	4.1	4.8	5.5	6.1	6.8	7.4	8.1	8.7	9.4	3
	23.0	23250	4.9	5.6	6.3	7.0	7.6	8.3	8.9	9.6	10.2	3
	24.0	27750	5.8	6.5	7.2	7.8	8.5	9.2	9.8	10.5	11.1	3
	25.0	32000	6.6	7.3	8.0	8.6	9.3	10.0	10.6	11.3	12.0	3

PEAK UNITGRAPH ORDINATE = 5420 CFS FLOOD STAGE R.O. = 0.54 IN.

INSTRUCTIONS

THE AMOUNT OF RAINFALL REQUIRED TO PRODUCE FLOOD STAGE APPEARING IN THE RFC ADVISORY FIXES THE APPROPRIATE COLUMN OF RAINFALL--CREST STAGE VALUES TO BE USED DURING THE ENSUING PERIOD. ENTER THE TABLE AT THAT COLUMN AND FOLLOW UP OR DOWN TO THE AVERAGE OBSERVED RAIN TO OBTAIN THE CORRESPONDING CREST STAGE. USE ALL AVAILABLE RAINFALL REPORTS IN THE BASIN ABOVE THIS STATION AND AVERAGE.

EXAMPLE..THE RFC ISSUES AN ADVISORY THAT 2.0 INCHES IS THE AMOUNT OF RAINFALL THAT WILL PRODUCE A FLOOD STAGE AT THIS STATION. THAT NIGHT AN AVERAGE OF 3.0 INCHES OF RAIN FALLS OVER THE BASIN ABOVE THIS STATION. ENTER THE TABLE ABOVE WITH A VALUE OF 2.0 AT FLOOD STAGE, 13.0 FEET. FOLLOW DOWN THAT COLUMN TO 3.0 AND READ A STAGE OF 18.0 FEET. THE LAG TIME SHOWN AT THE HEAD OF THE TABLE IS 9 HOUR(S), SO THE PREDICTION IS A CREST OF 18.0 FEET, 9 HOUR(S) FROM THE BEGINNING OF THE PERIOD OF HEAVIEST RAINFALL. USING THE SAME COLUMN AND LINE, READ ACROSS TO THE RIGHTHAND COLUMN TO FIND THE EXPECTED NUMBER OF HOURS FROM THE BEGINNING OF RAINFALL TO THE TIME THAT THE STREAM REACHES FLOOD STAGE. HENCE, IF THE HEAVY RAIN STARTED AT 7PM THE STREAM WOULD REACH FLOOD STAGE AT 12PM AND CREST AT 4AM THE FOLLOWING MORNING.

MAXIMUM STAGE OF RECORD

WALNUT CR.-W. DES MOINES,DES MOINES,IA NCRFC MAY 1990 DES HSA

ATTACHMENT C

FLOOD STAGE IS 11.0 FEET

LAG FROM BEGINNING OF THE TIME PERIOD OF HEAVIEST RAIN TO CREST IS 5 HOUR(S).

	STAGE FEET	DISCH. CFS	3 HOUR RAINFALL AMOUNTS (INCHES)									HRS FROM BGNG OF R.F TO FS
	8.0	2150	0.5	0.9	1.4	1.8	2.2	2.7	3.1	3.6	4.0	----
	9.0	2700	0.6	1.1	1.5	2.0	2.4	2.9	3.4	3.8	4.3	----
	10.0	3549	0.8	1.3	1.8	2.3	2.7	3.2	3.7	4.2	4.7	----
FS	11.0	4399	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5
	12.0	5649	1.2	1.8	2.3	2.8	3.3	3.9	4.4	4.9	5.4	4
	13.0	6899	1.5	2.0	2.6	3.1	3.7	4.2	4.7	5.3	5.8	3
	14.0	8200	1.9	2.5	3.0	3.6	4.1	4.7	5.3	5.8	6.3	3
	15.0	11000	2.3	2.9	3.5	4.1	4.7	5.2	5.8	6.4	6.9	2
	16.0	14000	2.9	3.5	4.1	4.7	5.3	5.9	6.5	7.1	7.6	2
	17.0	16999	3.6	4.2	4.8	5.4	6.0	6.6	7.2	7.8	8.3	2

PEAK UNITGRAPH ORDINATE = 4970 CFS FLOOD STAGE R.O. = 0.89 IN.

INSTRUCTIONS

THE AMOUNT OF RAINFALL REQUIRED TO PRODUCE FLOOD STAGE APPEARING IN THE RFC ADVISORY FIXES THE APPROPRIATE COLUMN OF RAINFALL--CREST STAGE VALUES TO BE USED DURING THE ENSUING PERIOD. ENTER THE TABLE AT THAT COLUMN AND FOLLOW UP OR DOWN TO THE AVERAGE OBSERVED RAIN TO OBTAIN THE CORRESPONDING CREST STAGE. USE ALL AVAILABLE RAINFALL REPORTS IN THE BASIN ABOVE THIS STATION AND AVERAGE.

EXAMPLE..THE RFC ISSUES AN ADVISORY THAT 2.0 INCHES IS THE AMOUNT OF RAINFALL THAT WILL PRODUCE A FLOOD STAGE AT THIS STATION. THAT NIGHT AN AVERAGE OF 3.5 INCHES OF RAIN FALLS OVER THE BASIN ABOVE THIS STATION. ENTER THE TABLE ABOVE WITH A VALUE OF 2.0 AT FLOOD STAGE, 11.0 FEET. FOLLOW DOWN THAT COLUMN TO 3.5 AND READ A STAGE OF 15.0 FEET. THE LAG TIME SHOWN AT THE HEAD OF THE TABLE IS 5 HOUR(S), SO THE PREDICTION IS A CREST OF 15.0 FEET, 5 HOUR(S) FROM THE BEGINNING OF THE PERIOD OF HEAVIEST RAINFALL. USING THE SAME COLUMN AND LINE, READ ACROSS TO THE RIGHTHAND COLUMN TO FIND THE EXPECTED NUMBER OF HOURS FROM THE BEGINNING OF RAINFALL TO THE TIME THAT THE STREAM REACHES FLOOD STAGE. HENCE, IF THE HEAVY RAIN STARTED AT 7PM THE STREAM WOULD REACH FLOOD STAGE AT 9PM AND CREST AT 12AM THE FOLLOWING MORNING

MAXIMUM STAGE OF RECORD

FLOOD STAGE IS 9.0 FEET

LAG FROM BEGINNING OF THE TIME PERIOD OF HEAVIEST RAIN TO CREST IS 5 HOUR(S).

	STAGE FEET	DISCH. CFS	3 HOUR RAINFALL AMOUNTS (INCHES)									HRS FROM BGNG OF R/F TO FS
	7.0	425	0.8	1.3	1.8	2.2	2.7	3.2	3.6	4.1	4.6	----
	8.0	500	0.9	1.4	1.9	2.3	2.8	3.3	3.8	4.3	4.8	----
FS	9.0	610	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5
	10.0	720	1.1	1.6	2.1	2.6	3.1	3.6	4.2	4.7	5.2	4
	11.0	859	1.2	1.7	2.2	2.8	3.3	3.8	4.4	4.9	5.4	3
	12.0	1000	1.2	1.8	2.4	2.9	3.4	4.0	4.5	5.1	5.6	3
	13.0	1199	1.4	1.9	2.5	3.1	3.6	4.2	4.7	5.3	5.8	3
	14.0	1399	1.5	2.1	2.7	3.2	3.8	4.4	4.9	5.5	6.1	2
	15.0	1662	1.6	2.2	2.8	3.4	4.0	4.6	5.2	5.7	6.3	2
	16.0	1924	1.7	2.3	3.0	3.6	4.2	4.8	5.4	6.0	6.5	2

PEAK UNITGRAPH ORDINATE = 3300 CFS FLOOD STAGE R.O. = 0.18 IN.

INSTRUCTIONS

THE AMOUNT OF RAINFALL REQUIRED TO PRODUCE FLOOD STAGE APPEARING IN THE RFC ADVISORY FIXES THE APPROPRIATE COLUMN OF RAINFALL--CREST STAGE VALUES TO BE USED DURING THE ENSUING PERIOD. ENTER THE TABLE AT THAT COLUMN AND FOLLOW UP OR DOWN TO THE AVERAGE OBSERVED RAIN TO OBTAIN THE CORRESPONDING CREST STAGE. USE ALL AVAILABLE RAINFALL REPORTS IN THE BASIN ABOVE THIS STATION AND AVERAGE.

EXAMPLE..THE RFC ISSUES AN ADVISORY THAT 2.0 INCHES IS THE AMOUNT OF RAINFALL THAT WILL PRODUCE A FLOOD STAGE AT THIS STATION. THAT NIGHT AN AVERAGE OF 2.5 INCHES OF RAIN FALLS OVER THE BASIN ABOVE THIS STATION. ENTER THE TABLE ABOVE WITH A VALUE OF 2.0 AT FLOOD STAGE, 9.0 FEET. FOLLOW DOWN THAT COLUMN TO 2.5 AND READ A STAGE OF 13.0 FEET. THE LAG TIME SHOWN AT THE HEAD OF THE TABLE IS 5 HOUR(S), SO THE PREDICTION IS A CREST OF 13.0 FEET, 5 HOUR(S) FROM THE BEGINNING OF THE PERIOD OF HEAVIEST RAINFALL. USING THE SAME COLUMN AND LINE, READ ACROSS TO THE RIGHTHAND COLUMN TO FIND THE EXPECTED NUMBER OF HOURS FROM THE BEGINNING OF RAINFALL TO THE TIME THAT THE STREAM REACHES FLOOD STAGE. HENCE, IF THE HEAVY RAIN STARTED AT 7PM THE STREAM WOULD REACH FLOOD STAGE AT 10PM AND CREST AT 12AM THE FOLLOWING MORNING

MAXIMUM STAGE OF RECORD

WALNUT CR-DALLAS COUNTY BR. NCRFC DEC 1989 DES HSA

```
708  **********************
708  DSMFLWDSM   3/13 1310
708  **********************
708  DSMFLWDSM
708  ETTAA00 KDSM 131311 COR
708
708  BULLETIN - IMMEDIATE BROADCAST REQUESTED
708  FLOOD WARNING   ...CORRECTION
708  NATIONAL WEATHER SERVICE DES MOINES IA
708  710 AM CST TUE MAR 13 1990
708
708  ...FLOOD WARNING FOR WALNUT AND FOUR MILE CREEKS IN THE DES MOINES
708  AREA...CORRECTED COPY..
708
708  HEAVY RAINS OF 2 TO 3 INCHES HAVE OCCURRED OVERNIGHT OVER THE WALNUT
708  CREEK AND FOUR MILE CREEK BASINS WHICH WILL CAUSE FLOODING ON THESE
708  CREEKS BY MID MORNING TODAY.
708
708  BASED ON RAINFALL RECEIVED UP TO 6 AM TODAY.. WALNUT CREEK WILL BE ABOVE
708  BANKFULL AT THE I35/80 BRIDGE IN CLIVE BY 8 AM TODAY AND PEAK AT 2 TO 3
708  FEET ABOVE THE 11 FEET FLOOD STAGE LATE THIS MORNING  AT 63RD ST IN DES
708  MOINES THE CREEK WILL GO OVER THE 13 FEET FLOOD STAGE BETWEEN 10 AND 11
708  AM TODAY AND CREST NEAR 16 FEET EARLY THIS AFTERNOON
708
708  ON FOUR MILE CREEK  THE CREEK WILL BE UP TO THE 12 FEET FLOOD STAGE BY
708  9 TO 10 AM THIS MORNING AT EASTON BLVD AND CREST NEAR 14 FEET AROUND
708  NOON TODAY.
708
708  ALL INTRESTS ALONG WALNUT AND FOUR MILE CREEKS SHOULD TAKE NECCESSARY
708  PRECAUTIONS TO PROTECT THEMSELVES AND THEIR PROPERTY FROM THIS FLOODING
708
708  THE NEXT STATEMENT WILL BE ISSUED BY 8 AM TODAY
708  ELM
708
708
708
708  -- End of AFOS product --
```

ATTACHMENT D

```
1244  NNNN
1244
1244  ********************
1244  MSPFFHIA     3/14 184E
1244  ********************
1244  MSPFFHIA
1244  ETTAA00 KMSR 141841
1244
1244    D E S   M O I N E S   H Y D R O L O G I C   S E R V I C E   A R E A
1244
1244  FLASH FLOOD/HEADWATER BASIN CREST STAGE GUIDANCE
1244  REFERENCE ROML C-40-82 FILED WITH CHAPTER E-13
1244  RELEASE DATE     WED MAR 14 1990
1244
1244  .B MSR 0314 DH12/PPTCF
1244
1244  :STREAM                  STATION                STAID    RAIN    RESTRICTIO
1244
1244  :TURKEY R                GARBER IA              GRBI4    1.20 :
1244  :LITTLE MAQUOKETA R      DURANGO IA             DRNI4    1.90 :
1244  :MAQUOKETA R             MANCHESTER IA          MNCI4    1.50 :
1244  :MAQUOKETA R             MAQUOKETA IA           MAQI4    1.20 :
1244  :WAPSIPINICON R          INDEPENDENCE IA        IDPI4    1.50 :
1244  :UPPER IOWA R            DORCHESTER IA          DORI4    1.10 :
1244  :STORM DITCH             MCGREGOR IA            MGGI4    1.10 :
1244  :DUCK CREEK              BETTENDORF IA          BETI4    2.10 :
1244  :WINNEBAGO R             MASON CITY IA          MCWI4    1.30 :
1244  :CEDAR R                 CHARLES CITY IA        CCYI4    2.00 :
1244  :BLACKHAWK CR            HUDSON IA              HUDI4    1.20 :
1244  :IOWA R                  MARSHALLTOWN IA        MIWI4    1.20 :
1244  :SQUAW CR                AMES IA                AMWI4    1.00 :
1244  :NORTH SKUNK R           SIGOURNEY IA           SIGI4    1.00 :
1244  :E FK DES MOINES R       ALGONA IA              AGNI4    1.00 :
1244  :LIZARD CR               CLARE IA               CLEI4    1.10 :
1244  :BOONE R                 WEBSTER CITY IA        WBCI4    1.40 :
1244  :BEAVER CR               GRIMES IA              GRMI4    1.30 :
1244  :FOUR MILE CR            DSM. I-80              FMAI4    1.00 :
1244  :FOUR MILE CR            DSM-EASTON             DFMI4    1.30 :
1244  :WALNUT CR.              DSM-DALLAS CTYBR       WCBI4    1.00 :
1244  :WALNUT CR.              DSM. I-35              WCAI4    1.40 :
1244  :WALNUT CR.              DSM-63RD ST            DOSI4    1.00 :
1244  :NORTH RACCOON R         JEFFERSON IA           EFWI4    1.00 :
1244  :NORTH RACCOON R         PERRY IA               PROI4    2.00 :
1244  :SOUTH RACCOON R         REDFIELD IA            REDI4    1.50 :
1244  :RACCOON R               VAN METER IA           VNMI4    1.00 :
1244  :NORTH R                 NORWALK IA             NRWI4    1.00 :
1244  :MIDDLE R                INDIANAOLA IA          IDNI4    1.00 :
1244  :SOUTH R                 ACKWORTH IA            AKWI4    1.20 :
1244  :CEDAR CR                BUSSEY IA              BSSI4    1.00 :
1244  :ELK RUN CR              WATERLOO IA            WECI4    2.00 :
1244  :VIRDEN CR               POND-WATERLOO          WZPI4    6.00 :
1244  :VIRDEN CR               RES-WATERLOO           WZRI4    1.70 :
1244  :MAD CR                  MUSCATINE-HY 38 IA     MMCI4    2.80
1244
1244  .END NCRFC
1244
1244
1244
1244  -- End of AFOS product --
```

ATTACHMENT E

ECONOMIC AND SOCIAL ANALYSIS

APPENDIX B

DESIGN MEMORANDUM
FOR
FLOOD CONTROL PROJECT
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA

APPENDIX B
ECONOMIC AND SOCIAL ANALYSIS

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DESIGN MEMORANDUM
FOR
FLOOD CONTROL PROJECT
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA
APPENDIX B
ECONOMIC AND SOCIAL ANALYSIS

SECTION 1 - INTRODUCTION

PURPOSE

This appendix describes the economic and social analysis relating to the selected plan (100-year design levee) for providing flood damage reduction measures for the cities of West Des Moines and Des Moines, Iowa. Current damages are caused primarily by high flows of the Raccoon River, and Walnut Creek, a tributary. The six major sections of this appendix summarize the Design Memorandum (GDM) analysis conducted by the Rock Island District, U.S. Army Corps of Engineers. Other alternatives, options and levels of protection were evaluated in the General Reevaluation Report, approved September 1989.

Following the introductory section, the second section describes the general characteristics of the study area and summarizes historical flood damages. The third section presents the procedures used to determine flood damages and the potential benefits which would accrue to a flood damage reduction project. The fourth section presents the benefit and cost analysis for the recommended plan. The fifth section summarizes the non-Federal financial analysis. Section six discusses the social impacts of the proposed project. Throughout this analysis, price levels are stated as of July 1990, with the Federal discount rate of 8-7/8 percent for water resource projects being used to amortize costs and to discount benefits to a common period of time.

SECTION 2 - CHARACTERISTICS OF THE STUDY AREA

GENERAL

This section describes the project area and its existing conditions in terms of physical characteristics and flooding problems, with a brief discussion of likely future conditions.

EXISTING CONDITIONS

The cities of West Des Moines and Des Moines comprise the major portion of the Des Moines Standard Metropolitan Area (SMA), which includes sections of Polk, Dallas, and Warren Counties. This SMA has a 1990 estimated population of 389,800 which is a 5.6 percent increase from the 1980 census. Interstate Highways 35 and 80, as well as other major roadways, intersect at Des Moines. The city is served by major air and railway lines, and is the hub of the State's transportation system. Des Moines is the State capitol, and the area is a well-diversified commercial and industrial center.

As shown on plate 1 of the main report, the project area is located on the north bank of the Raccoon River about 6 miles upstream from its confluence with the Des Moines River. Plate B-1 of this appendix identifies the economic reaches.

The project site (Raccoon River and Walnut Creek floodplains) is an approximate 900-acre area with concentrations of residential neighborhoods, commercial development, industrial sites, and public facilities. Table B-1 lists the types of properties in the project area, which is divided into five economic reaches. These reaches were segregated based on similarities of hydrologic impacts.

TABLE B-1

Floodplain Characteristics
Number of Properties

Reach Number	Residential	Commercial	Industrial	Public
1	2	37	1	1
2	102	8		1
3	251	2		1
4	440	145		5
5	109	25	9	3
TOTALS..	904	217	10	11

SOCIOECONOMIC CONDITIONS

As shown in table B-2, 1985 data indicate that the Des Moines area labor force is concentrated in wholesale and retail trade and professional and related services. Household income averaged $23,750 in the Des Moines SMA, compared to $21,770 in the State of Iowa. SMA income is concentrated in service industries, wholesale and retail trade, and manufacturing. Comparative population and socioeconomic trends are shown in tables B-3 and B-4.

TABLE B-2

Des Moines, Iowa, SMA Labor Force
1985

Employment Category	Labor Force	Percent Distribution
Manufacturing	24,250	14.1
Wholesale and Retail Trades	42,300	24.6
Professional and Related Services	35,260	20.5
Other Significant Industries (Finance, Insurance, Real Estate)	19,780	11.5
Government	27,500	16.0
Construction	8,600	5.0
Transportation	7,910	4.6
All Other	6,360	3.7

TABLE B-3

Population Trends
(Thousands)

	Pop. 1970	1980	Pop. Proj. 1990	Change Percent 1970-1980	Change Percent 1980-1990
City of West Des Moines, IA	16.4	21.9	29.0	+33.5	+32.4
City of Des Moines, IA	201.4	191.0	196.7	- 5.2	+ 3.0
Polk County, IA	286.1	303.2	316.1	+ 6.0	+ 4.3
Des Moines, IA SMA	341.5	369.2	389.8	+ 8.1	+ 5.6
State of Iowa	2825.0	2913.8	2913.5	+ 3.1	0

TABLE B-4

1985 Comparative Socioeconomic Data

Item	Des Moines Standard Metropolitan Area	State of Iowa
Median Household Income	$23,750	$21,770
Median Housing Unit Value	$54,700	$46,500
High School Graduates (%)	77.0	71.7
Age 65 Years or Older (%)	11.0	13.2

FLOOD HISTORY

The cities of West Des Moines and Des Moines, Iowa are prone to severe flooding from the Raccoon River and Walnut Creek. Flood events are often independent, but are sometimes concurrent. To eliminate the potential for double counting, damages in reaches with possible concurrent flooding were evaluated based only on the controlling stream frequency/elevation relationship (i.e., the stream producing the greatest damage within the reach). Walnut Creek is the controlling stream for Reaches 1 and 2, while the Raccoon River controls Reaches 3, 4, and 5.

The most recent severe flooding occurred in May 1986 and July 1986 on Walnut Creek and the Raccoon River, respectively. The May 1986 flood (Walnut Creek) caused more than $3 million in damage to 46 businesses and 220 homes. This flood was an approximate 40-year event, and actual damage fits well into the project damage curve. The July 1986 flood (Raccoon River) was an approximate 30-year event. Serious commercial and residential damages were prevented by construction of an emergency levee (at a West Des Moines city-cost of $45,000).

Significant flooding has occurred from the Raccoon River in 1947 (record flood), 1973, 1979 and 1990. Damaging floods occurred from Walnut Creek in 1973, 1974, 1975, and 1990.

MOST PROBABLE FUTURE CONDITION

The most likely future condition in the project area of Des Moines-West Des Moines, Iowa, is increased flood problems. Both cities have a diversified and expanding economic base, with the potential for greater damageable value in the future. Also, continued upland development will likely increase future runoff and flooding severity.

SECTION 3 - METHODS TO DETERMINE POTENTIAL FLOOD DAMAGE REDUCTION BENEFITS

ANALYSIS OF POTENTIAL FLOOD DAMAGE

CREDIT FOR EXISTING LEVEES

No protection credit has been assigned to the existing levee along a downstream portion of Walnut Creek. There are three sound reasons for this decision:

1.) During flood events (i.e. 1986), waters flowed behind the upstream end of the levee, as there is no high-ground tie off; 2.) The existing levee is an aging agricultural levee, not built to Corps of Engineers standards; 3.) Economic evaluation of the reach behind the existing levee is based only on Raccoon River flows (controlling stream).

Also, no credit has been assigned to the Raccoon River emergency levee built during the 1986 flood threat, due to its temporary purpose and construction design.

RESIDENTIAL STRUCTURES

Each residential structure in the floodplain was surveyed by Corps of Engineers personnel to establish its ground elevation, first floor elevation, structure type, and estimated repair/replacement value. This information was then analyzed using the residential damage program for the Rock Island District. Content value was estimated to be 34 percent of a residential structure's value. Residential damage-frequency curves were constructed for each reach in the study area. Table B-5 depicts residential damages by reach for various flood event frequencies.

TABLE B-5

Residential Damage by Reach
Existing Conditions ($1,000's)
(Structure and Content)

Flood Frequency	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
.5					
.2	0	0	0	0	0
.1	0	29	170	3,010	583
.05	0	59	725	5,361	956
.02	0	110	1,897	7,016	1,340
.01	5	264	3,062	7,825	1,502
.005	13	493	4,228	8,423	1,645
.002	26	786	5,159	8,954	1,772
SPF	40	1,203	6,652	11,218	2,356

COMMERCIAL AND INDUSTRIAL DAMAGES

The project area of West Des Moines-Des Moines, Iowa is a varied and growing site of commercial activity. Commercial businesses represented in the study area have an estimated structural and content value of $25 million and $20 million, respectively. These businesses include: retail and wholesale lumber, building products, brick and tile, realty and banking, laundering, printing, bowling lanes, supermarkets, auto service stations, restaurants, hardware, taverns, veterinary services, pharmacies, furniture, law offices, appliances, florists, clothiers, hair salons, chiropractic services, bakery distribution, paints, trucking, plumbing, electronics, optical services, wholesale foods, insulation, gifts, antiques, bookstores, pawnshops, jewelers, lawn and garden, janitorial service, tree service, and ready-mix concrete. Industrial concerns have an estimated structural and content value of $11 million and $30 million, respectively, and include: packaging, concrete products, cement plant, bulk fertilizer, metal fabrication, plating, and turbine manufacturing.

To establish depth-damage relationships, interviews were conducted with business and industry representatives in the flood-prone areas. Since recent serious flooding has occurred (1986), much actual damage information was readily available. Tables B-6 and B-7 relate commercial and industrial damages by reach and flood frequency.

TABLE B-6

Commercial Damages ($1,000's)
Existing Damages

Flood Frequency	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
.5	0	0	0	0	0
.2	1,709	0	0	0	0
.1	2,580	0	8	4,970	780
.05	3,104	10	16	6,790	1,374
.02	3,850	31	21	7,865	2,055
.01	4,472	114	22	8,508	2,500
.005	4,950	278	23	9,022	2,776
.002	5,430	587	26	9,510	3,095
SPF	5,950	958	50	11,200	3,816

TABLE B-7

Industrial Damages ($1,000's)
Existing Conditions*

Flood Frequency	Reach 1	Reach 5
.5	0	0
.2	31	0
.1	192	230
.05	375	528
.02	1,725	1,505
.01	3,575	2,409
.005	4,555	3,166
.002	5,100	3,792
SPF	5,600	5,145

*Reaches 2, 3, and 4 contain no industrial concerns.

PUBLIC DAMAGE

Public properties in the West Des Moines portion of the project area include the City Hall, the Water Works office and plant, Board of Education offices and an elementary school, two parks, Public Works and Engineering offices, a community center, U.S. Post Office, and roads and sewers. Public property damages in the Des Moines portion include an equalization basin, roads, and sewers. Table B-8 depicts public damage, by reach, over the range of possible flood events.

TABLE B-8

Public Damage by Reach ($1,000's)
Existing Conditions

Flood Frequency	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
.5	0	0	0	0	0
.2	8	0	0	0	0
.1	11	9	6	288	67
.05	15	17	10	405	112
.02	21	23	16	506	172
.01	31	28	19	577	242
.005	38	32	23	640	359
.002	52	36	27	707	432
SPF	70	41	39	961	742

EMERGENCY COSTS

During flood threats, both cities engage in emergency flood-fighting operations. Costs are incurred for sandbagging, temporary dikes and pumping, as well as associated personnel costs. During the 1986 flood events, the two cities spent approximately $42,000 and $99,000 for Walnut Creek and Raccoon River flood-fighting, respectively. These costs were projected over the full range of flood events to construct an emergency cost curve.

FUTURE CONSIDERATIONS

Residential Content

The residential affluence concept refers to an increase in accumulated housing content value over time. Based on current OBERS projections for per capita income growth, residential content value is projected to increase 1.57 percent annually to 50 percent of structural value from the present 34 percent. The content value is projected to reach its maximum (50%) after 25 years. Thus, damages to residential contents will increase over time in the without-project years.

Commercial and Industrial Expansion

Business expansion in the project area since the Feasibility Report is obvious, with an approximate 30 percent increase in the number of businesses at the site. New construction and greater numbers of businesses are very evident. Some of this growth has occurred in the flood plain fringes and on filled land (regulated floodplain). However, most growth has taken place at existing buildings, with expansion of facilities or reoccupation of vacant premises. This multi-component growth trend is expected to continue.

Establishing a growth rate projection for expansion of flood-damageable property is difficult, at best. During interviews, expansion of facilities and activity was the predominant view. Large increases in capacity were often forecasted such as 25 to 50 percent expansions in the near term. As is often the case, written or formal strategic business plans are not available (especially in small businesses). Therefore, establishing growth rates based on interviews is not realistic.

This analyst believes that the use of generalized growth projections (OBERS) presents a more reliable, reasonable, acceptable, and conservative means for incorporating future growth into the economic analysis. Based on the 1985 OBERS Regional Projections for the Des Moines SMA, commercial damageable property is expected to increase at a 2 percent annual rate for 30 years after the base year (with a no-growth scenario for remaining project life). An average of wholesale, retail, and service sector projections was used for this index. The OBERS manufacturing index (1.4 percent growth for same period) was used for industrial property expansion. The use of these generalized growth rates has no distorting effects on project evaluation.

AVERAGE ANNUAL DAMAGES

Average annual damages are the expected value of flood losses for any given year. To calculate average annual damages, depth-damage curves for project area properties were integrated with elevation-frequency relationships. Table B-9 summarizes annual damages by major category and decade.

INTERIOR FLOODING - JORDAN CREEK

Jordan Creek, which forms the southwestern border of the project area, has the potential to cause nuisance flooding in the with- and without-project condition. During a 25-year event or greater, in the with-project condition, Jordan Creek waters could flow behind the downstream (Raccoon River) flank levee tie-off. Water could pond behind the levee and be released through a gravity outlet. Damages would be insignificant and would occur with or with-out the project.

TABLE B-9

Average Annual Damages ($1,000's)

	Year	Residential Structure	Residential Content	Commercial	Industrial	Public	Total
	1990	593.0	332.0	1,815.0	236.0	75.9	3,051.9
BaseYear	1996	593.0	359.0	2,004.0	252.0	75.9	3,283.9
	2006	593.0	419.5	2,443.0	289.0	75.9	3,820.4
	2016	593.0	490.2	2,978.0	332.0	75.9	4,469.1
	2026	593.0	528.0	3,630.0	356.0	75.9	5,182.9
	2036	593.0	528.0	3,630.0	356.0	75.9	5,182.9
	2046	593.0	528.0	3,630.0	356.0	75.9	5,182.9
	2096	593.0	528.0	3,630.0	356.0	75.9	5,182.9
Discounted at 8-7/8 Percent							
	1990	593.0	332.0	1,815.0	236.0	75.9	3,051.9
	1996	593.0	359.0	2,004.0	252.0	75.9	3,283.9
	1996-2096	593.0	423.9	2,538.0	388.0	75.9	4,018.8

TABLE B-10

Flood Damage Reduction Benefits
By Category and Time Period
(100-Year Project, 8-7/8%, $1,000's)

	Year	Residential Structure	Residential Content	Commercial	Industrial	Public	Total
	1990	534.0	301.0	1,717.0	190.0	69.0	2,811.0
BaseYear	1996	534.0	331.0	1,896.0	203.7	69.0	3,033.7
	2006	534.0	386.8	2,311.0	234.0	69.0	3,534.8
	2016	534.0	451.0	2,817.0	270.0	69.0	4,141.0
	2026	534.0	487.5	3,110.0	289.0	69.0	4,489.5
	2036	534.0	487.5	3,110.0	289.0	69.0	4,489.5
	2046	534.0	487.5	3,110.0	289.0	69.0	4,489.5
	2096	534.0	487.5	3,110.0	289.0	69.0	4,489.5
Discounted at 8-7/8 Percent							
	1990	534.0	301.0	1,717.0	190.0	69.0	2,811.0
	1996	534.0	331.0	1,896.0	203.7	69.0	3,033.7
	1996-2096	534.0	391.1	2,294.0	231.7	69.0	3,519.8

DOWNSTREAM EFFECTS AND INDUCED DAMAGES

The proposed project will have no effects on downstream properties. Based on with-project hydraulic profiles, induced damages to residential properties near the left (northeast) bank of Walnut Creek are approximately $200 annually. Commercial properties on the left bank of Walnut Creek (near Grand Avenue) will realize no significant increase in annual damages.

SECTION 4 - BENEFIT-COST ANALYSIS

Throughout this analysis, benefits and costs are stated in July 1990 price levels. A 100-year project life and a discount rate of 8-7/8 percent were used to amortize costs and discount benefits to a common time period. Interest during construction was calculated based on a 5-year construction period. Annual operation and maintenance charges were added to amortized first costs to determine total annual charges to be compared with annual benefits.

BENEFIT ANALYSIS

FLOOD DAMAGE REDUCTION

The General Revaluation Report (GRR-approved September 1989) evaluated various project alternatives and levels of protection. The GRR optimization analysis indicated that the 100-year design would maximize net NED benefits. The Design Memorandum report discusses the benefits and costs of the selected 100-year design levee project.

Benefits accruing from reduction of flood damages are computed as the difference between with-project and without-project average annual damages. Table B-10 details existing and future flood damage reduction benefits by category and time period. Benefits in the freeboard range are included in the categorical totals. They are calculated as one-half the area under the damage-frequency curve between the design level of protection and the largest flood which might be carried within the freeboard. Residual damages are those damages which will occur with the proposed project in place (due to flood events greater than project design levels). Table B-11 presents a summary of the benefits and the residual (with-project) damages for the 100-year levee and floodwall project.

TABLE B-11

Average Annual Benefits ($1,000's)
Flood Damage Reduction
100-Year Project Design

Category	Benefits			Residual Damage	Average Annual Damage
	Existing	Future	Total		
Residential	865.0	60.1	925.1	91.8	1,016.9
Commercial	1,896.0	398.0	2,294.0	244.0	2,538.0
Industrial	203.7	28.0	231.7	156.3	388.0
Public	69.0	-	69.0	6.9	75.9
TOTALS	3,033.7	486.1	3,519.8	499.0	4,018.8

FLOOD INSURANCE SAVINGS

The administration of the Flood Insurance Program is a national cost. Savings of this administrative cost can be credited to a project as a National Economic Development (NED) benefit if the project protects an area located in the 100-year (1 percent exceedence frequency) floodplain. It is assumed that all properties in the 100-year floodplain participate in the Flood Insurance Program and that coverage will be eliminated if flood protection is provided. Current annual administrative costs are estimated to be $79 per policy. With a total of 1,048 properties in the indicated floodplain, $82,900 in insurance cost savings would accrue to the proposed project annually.

RECREATION BENEFITS

The West Des Moines project area is located within the Des Moines Recreational River and Greenbelt boundary.

The September 1987 General Design Memorandum for the Greenbelt identified recreation amenities required to fulfill current and projected demand within the Greenbelt area. Needs were based on current visitation or usage, population projections, activity use rate projections, latent demand, and recreation planning space standards. This market analysis supported the construction of additional boat ramp launch lanes and multi-use trails.

Boat Ramps. The Greenbelt market analysis reported a need for at least 140 launch lanes within the area by 1995. Only 124 launch lanes exist in the Greenbelt boundaries, with an additional seven lanes scheduled for construction. Construction of a single-lane boat ramp, as part of the West Des Moines project, would help fulfill the latent and projected demand for launch lanes in the Greenbelt area.

Trails. The Greenbelt General Design Memorandum supported the construction of an additional 400 miles of bike trails within the 9-county area. These trails would be needed in addition to the 108 miles of existing bike trail. Construction of a 3-mile length of multi-use trail (bike, hike, jog, walk) would help fulfill the demand for bike trails. This trail would provide a safer and more enjoyable recreation experience than alternative use of city roads.

The construction of the proposed recreation facilities as part of the West Des Moines project would result in no adverse impacts to similar existing facilities; in particular, no decrease in visitation at other facilities would result.

The biking (walking, jogging, etc.) trail will be constructed on the levee crown, running approximately 15,000 feet in length. The single ramp boat launch (with parking) will be built for Raccoon River access, to accommodate small craft (fishing and canoeing). The benefits for these recreational facilities have been assessed using the Unit Day Value (UDV) method, as prescribed by The Principles and Guidelines (P&G). The following tables depict UDV assignments and the resulting use valuations. For the bicycle trail evaluation (table B-12) a comparison is made for the without-trail condition (e.g., street biking/running).

As shown in table B-12, the annual benefit for the bicycle trail segment of the project is $35,000. The estimated usage of 70,000 per year is based on space and turnover standards for recreation planning. Table B-13 depicts the UDV point assignment and use valuation for the proposed boat ramp facility.

TABLE B-12

Bicycle/Activities Trail
Recreation Benefit Evaluation
Unit Day Value Method

Criteria	Point Assignments No Trail	Trail	Comments
Recreation Exposure	5	7	Several general activities. Trail provides safer, more consistent experience
Availability of Opportunity	1	2	Several within one hour; a few within 30 minutes
Carrying Capacity	2	7	Minimum facility without trail; adequate facility with trail
Accessibility	12	12	Good access to & within site
Environmental Quality	2	5	Low aesthetics without trail; average with trail
TOTAL POINTS	22	33	
1990 P&G Value	$2.84	$3.34	
Difference (Value Increase)	$0.50		
Estimated Annual Usage	x 70,000		
ANNUAL BENEFIT	$35,000		

TABLE B-13

Boat Ramp Benefit Evaluation
Unit Day Value Method

Criteria	Point Assignment	Judgment Factors
Recreation Experience	5	Several general activities
Availability of Opportunity	2	Several within one hour; a few within 30 minutes
Carrying Capacity	4	Basic facility to conduct activities
Accessibility	12	Good access to and within site
Environmental Quality	5	Average aesthetic quality
TOTAL POINTS	28	
1990 P&G Value	$3.11	
Estimated Annual Use	x 12,000	
ANNUAL BENEFIT	$37,300	

The annual benefit for the proposed boat ramp is $37,300. The recreational boating demand in the study area was estimated using a regional gravity allocation model. The model is used to determine the launch distribution of various user populations to alternative destination launch sites. Based on the location and capacity of the proposed boat ramp, 12,000 annual uses are estimated (4,000 launches x 3-person average per launch).

A cost and benefit summary for recreation features is detailed in table B-14. The recreation facilities are incrementally justified with a benefit-to-cost ratio (BCR) of 1.8.

TABLE B-14

Cost and Benefit Summary
Recreational Facilities

Recreation Facilities:	
Cost Estimate (100-Year Project)	$402,000
Interest During Construction	17,800
Total First Cost	$419,800
Annual Cost, 100-Years, 8-7/8%	$ 40,200
Interest & Amortization	(37,300)
Operation, Maintenance & Replacement	(2,900)
Annual Benefits	$ 72,300
Bicycle Trail	(35,000)
Boat Ramp	(37,300)
BCR	1.8

SUMMARY OF THE BENEFIT-COST ANALYSIS

Table B-15 summarizes the benefit-cost analysis for the 100-year design project. This plan provides net benefits of $1,849,800 and is the NED plan. This plan has a BCR of 2.0. Tables B-16 and B-17 present the calculations for interest during construction and for annualizing project costs. Appendix D of this report presents a detailed cost estimate for the recommended plan.

TABLE B-15

Benefits and Costs Summary
100-Year Levee Project Design
(8-7/8%, 100-Year Life, July 1990 Prices, $1,000's)

Item	100-Year
Annual Benefits-Total	3,658.2
Existing (Includes Freeboard Range)	(3,099.8)
Residential Damage Reduction 1/	844.1
Commercial 1/	1,880.7
Industrial	203.7
Public	69.0
Flood Insurance Savings	82.9
Emergency Costs	19.4
Future	(486.1)
Residential Affluence	60.1
Commercial Growth	398.0
Industrial Growth	28.0
Recreation Benefits	(72.3)
Cost Estimate:	
Federal	12,193.5
Non-Federal	4,198.5
Interest During Construction	3,597.0
Annual Charges-Total	1,808.4
Interest and Amortization	(1,774.4)
Operation and Maintenance	(34.0)
Net Annual Benefits - Existing Flood Control	1291.4
BCR - Existing Flood Control	1.7
Net Annual Benefits - Total	1,849.8
BCR - Total	2.0

1/ Existing benefits for Residential and Commercial Properties were reduced by $20,900 and $15,300, respectively, to reflect interior drainage residual damages due to blocked gravity conditions in the with-project condition.

TABLE B-16

Interest During Construction
100-Year Design Project - 8-7/8% Discount Rate

Fiscal Year	Expenditures (1,000's) Federal	Non-Federal	Time to Base Year (Periods)	Interest Factor of $1 Deposited to Base Year	Accumulated Interest to Base Year (1,000's) Federal	Non-Federal	Total
1992	1,200.0	600.0	4.5 (9)	.47811	574.0	287.0	861.0
1993	450.0	1,400.4	3.5 (7)	.35517	160.0	497.0	657.0
1994	3,600.0	951.0	2.5 (5)	.24246	872.0	231.0	1,103.0
1995	5,400.0	1,074.1	1.5 (3)	.13912	751.0	149.0	900.0
1996	1,543.5	173.0	0.5 (1)	.04437	68.0	8.0	76.0
TOTALS	12,193.5	4,198.5			2,425.0	1,172.0	3,597.0

TABLE B-17

Summary of Annual Charges ($)
100-Year Design Project
(8-7/8%, 100-Year Life)

Description	Amount Federal	Non-Federal	Total
Estimated Economic First Cost	12,193,500	4,198,500	16,392,000
Interest During Construction	2,425,000	1,172,000	3,597,000
Total Economic First Costs	14,618,500	5,370,500	19,989,000
Interest and Amortization (.08877)	1,297,700	476,700	1,774,400
Operation and Maintenance	0	34,000	34,000
Total Annual Charges	1,297,700	510,700	1,808,400

SECTION 5 - FINANCIAL ANALYSIS

COST DISTRIBUTION

Based on current cost-sharing provisions, Federal and non-Federal costs will be distributed as in table B-18.

TABLE B-18

Project Cost Distribution - 100-Year Design
West Des Moines - Des Moines Project

Total Project Cost Estimate	$16,392,000		
Federal Cost Estimate	12,193,500	West	
Non-Federal Cost Estimate		Des Moines	Des Moines
Lands, Damages, & Relocations		$2,190,000	$ 835,500
Cash Contributions		891,100	281,900
Total Non-Federal Cost Estimate (26% of Total Project Cost)		$3,081,100	$1,117,400

ABILITY TO PAY

Based on the provisions of Section 103 of Public Law 99-662, the cities of West Des Moines and Des Moines have the ability to provide their normal share of project costs. The analysis, illustrated in table B-19, is based upon the 100-year project BCR and the project-area per capita income. The cities do not qualify for reduced cost-sharing.

TABLE B-19

Ability to Pay Analysis

Project: West Des Moines and Des Moines, Iowa

Annual Cost	$ 1,808,400	Cost & Benefits
Annual Benefits	3,658,200	for Flood Control
Total Cost	16,392,000	
Local Share	4,198,500	
BCR	2.0	
State Factor	91.39	Sum of State &
County Factor	107.86	County Must be
		Less Than 163.2
		Sum is 199.25
NOT QUALIFIED		
Base Benefits Floor	51%	1/4 BCR
% Local Share	26%	
EF	-3.19	Eligibility Factor

FINANCIAL CAPABILITY

The cities of West Des Moines and Des Moines have the willingness and capability to finance their shares of the cost of constructing this local flood protection project. A Statement of Financial Capability and Financing Plan will be submitted as an addendum to the Design Memorandum.

SECTION 6 - SOCIOECONOMIC IMPACTS

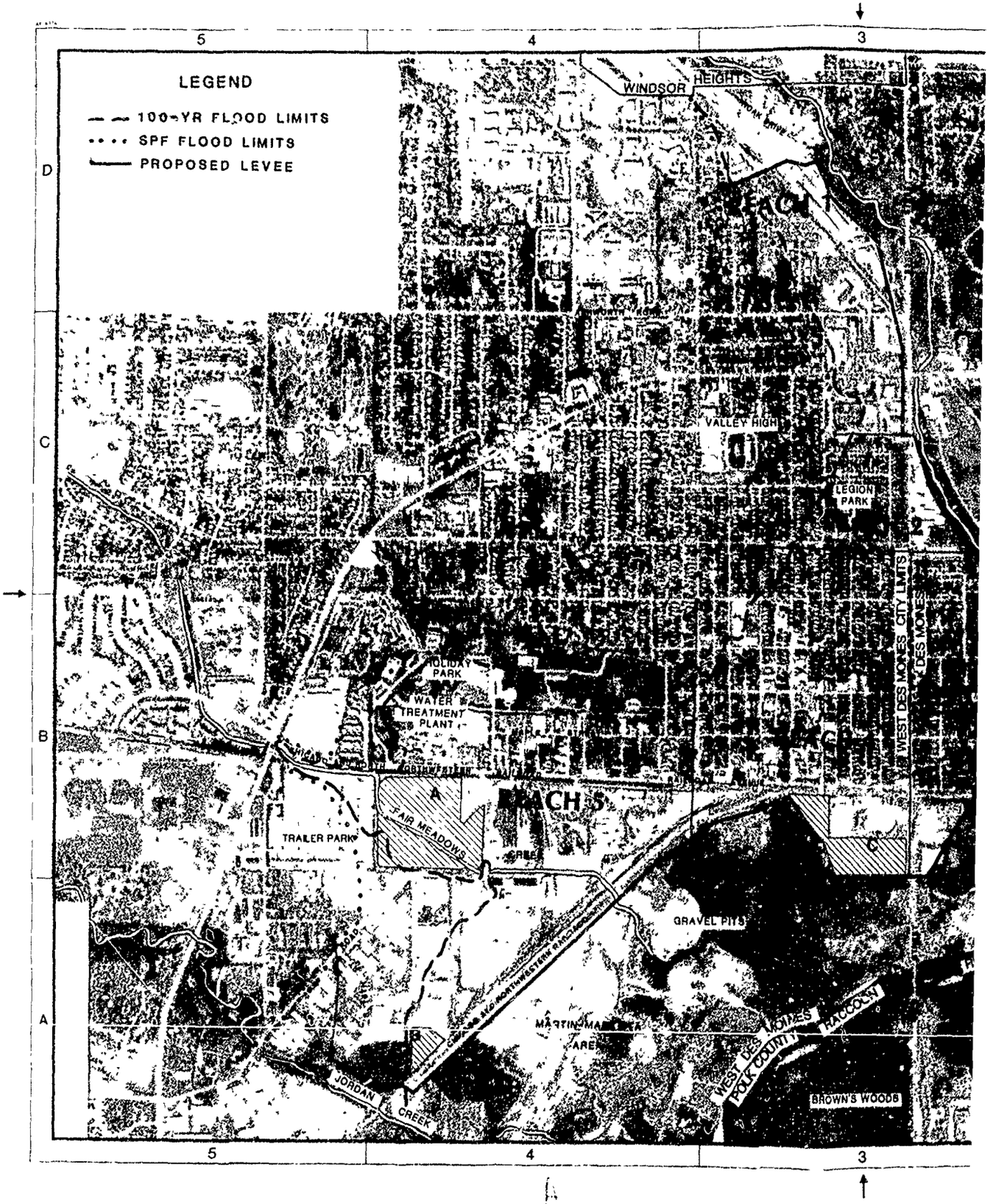
DISCUSSION OF IMPACTS

This section presents a summary of socioeconomic impacts which would be associated with the proposed 100-year design project at West Des Moines - Des Moines, Iowa.

The project involves construction of flood damages reduction measures, (e.g., levees, floodwalls), at West Des Moines - Des Moines. The socioeconomic impacts associated with this project generally would be positive. Affected residents and property owners would experience increased community cohesion and would be less likely to move from the project area. Services to and from the affected area would be better maintained, and public facilities would benefit from reduced like, health, and safety risks associated with flood events.

The project would necessitate one business relocation. Opportunity exists for the affected business to relocate to an acceptable location within the project area. The relocations would result in no significant impact to the community.

No long-term impacts to area noise levels would result form the project, although temporary increases in noise levels would be experienced during project construction. Impacts to area aesthetics would be minimized by planting vegetation along the levee segments visible from residential and business areas, and by minimizing the use of flood walls. A more detailed discussion of socioeconomic impacts is provided in the Supplemental Environmental Impacts Statement.


LEGEND
100-YR FLOOD LIMITS
SPF FLOOD LIMITS
PROPOSED LEVEE
WINDSOR HEIGHTS
VALLEY HIGH
LEGION PARK
WEST DES MOINES CITY LIMITS
HOLIDAY PARK
WATER TREATMENT PLANT
FAIR MEADOWS
TRAILER PARK
GRAVEL PITS
JORDAN CREEK
BROWN'S WOODS
5
4
3
A
B
C
D

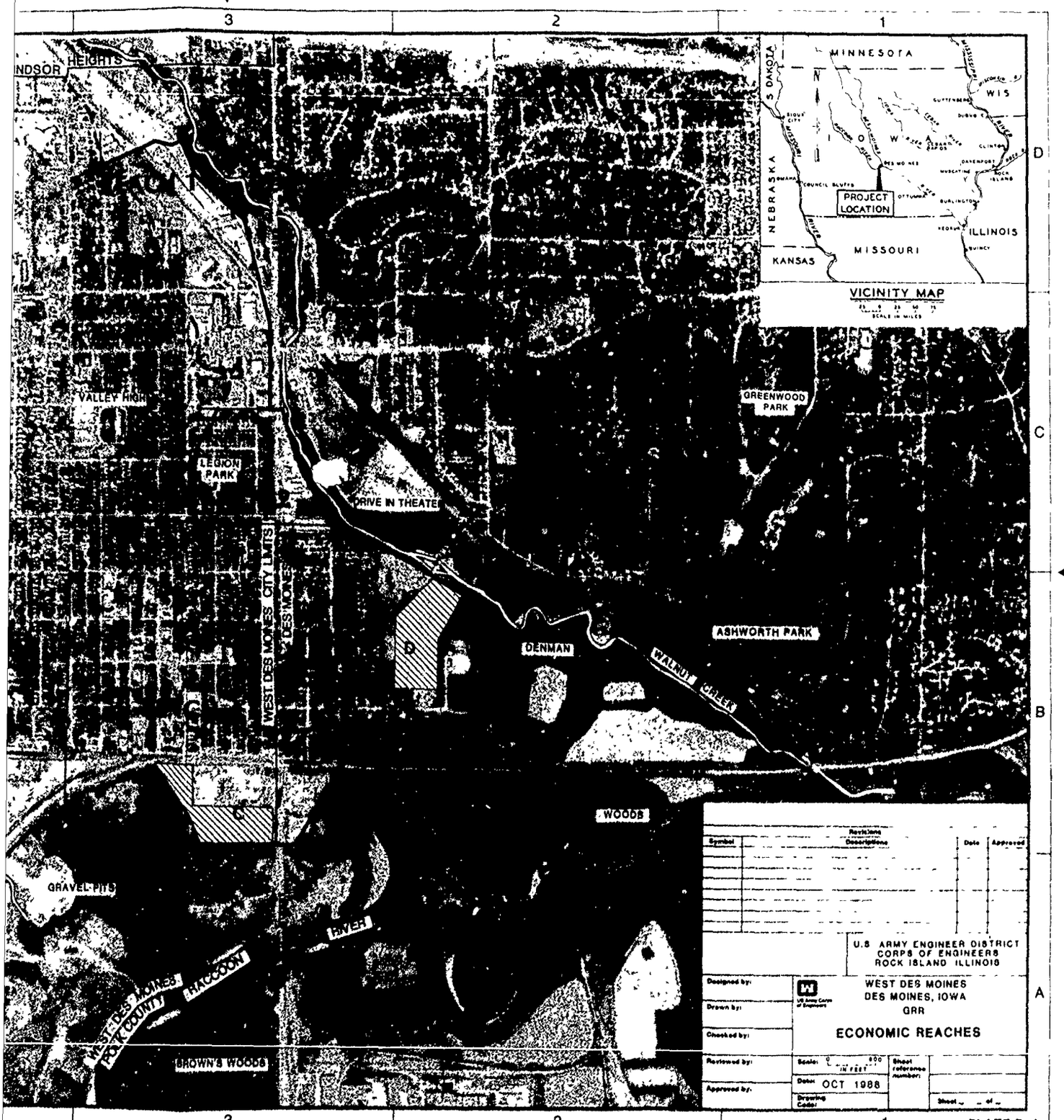

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NDSOR HEIGHTS
VALLEY HIGH
LEGION PARK
DRIVE IN THEATE
GREENWOOD PARK
WEST DES MOINES CITY LIMITS
DES MOINES
DENMAN
ASHWORTH PARK
WALNUT CREEK
WOODS
GRAVEL PITS
RIVER
RACCOON
W. DES MOINES
POLK COUNTY
BROWN'S WOODS
MINNESOTA
S DAKOTA
NEBRASKA
WIS
ILLINOIS
MISSOURI
KANSAS
PROJECT LOCATION
VICINITY MAP
Revisions
Symbol
Description
Date
Approved
U.S ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND ILLINOIS
Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:
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DES MOINES, IOWA
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PLATE B-1

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GEOTECHNICAL

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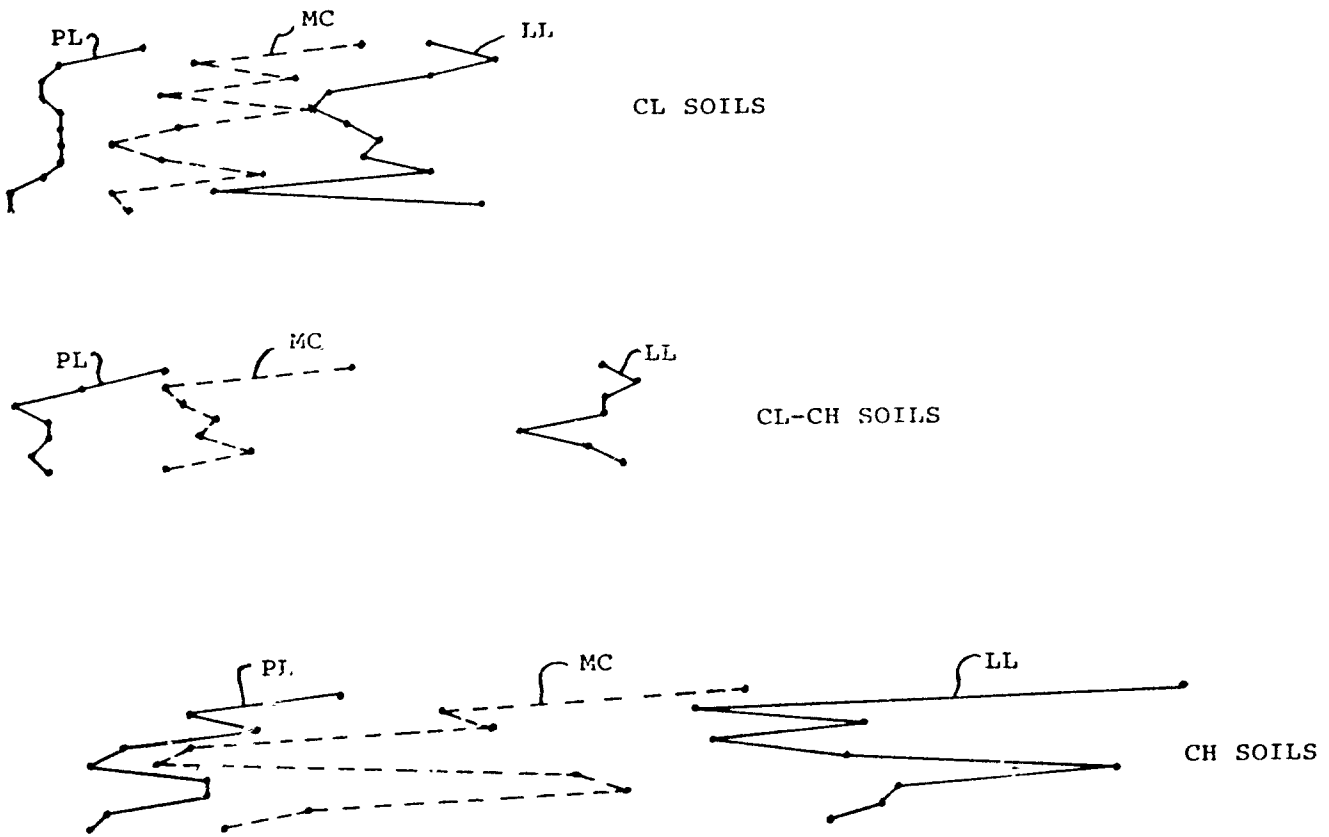
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WEST DES MOINES - DES MOINES, IOWA
TABULATION OF ATTERBERG LIMITS AND MOISTURE CONTENTS

BORING NO.	SOIL TYPE	MOISTURE CONTENT	ATTERBERG LIMITS
WDM-65-17	CL-CH	36	51/25
WDM-65-25	CH	59	85/35
WDM-65-26	CH	41	56/26
WDM-65-41	CH	44	66/30
WDM-65-42	CL	37	41/24
WDM-89-53	CL	27	45/19
WDM-89-55	CL-CH	25	53/20
WDM-89-55	CL	33	41/18
WDM-89-57	CL	25	35/18
WDM-89-58	CL	34	34/19
WDM-89-59	CL	26	36/19
WDM-89-62	CH	26	57/22
WDM-89-62	CL-CH	26	51/16
DM-89-64	CL-CH	28	51/18
WDM-89-66	CL (FILL)	14	32/17
WDM-89-66	CL	22	38/19
WDM-89-68	CL-CH	27	46/18
WDM-89-69	CL	25	37/19
WDM-89-72	CL	31	41/18
WDM-89-73	CL-CH	30	50/17
WDM-89-78	CH	24	65/20
WDM-89-79	CH	49	81/27
WDM-89-80	CH	52	68/27
WDM-89-81	CH	33	67/21
WDM-89-82	CL	22	28/16
WDM-89-85	CL	23	44/16
WDM-89-86	CL-CH	25	52/18
WDM-89-87	CH	28	64/20

NOTE: Reference plate C-48



WEST DES MOINES - DES MOINES, IOWA

Atterberg Limits and Moisture Content Correlation

PLATE C-49

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

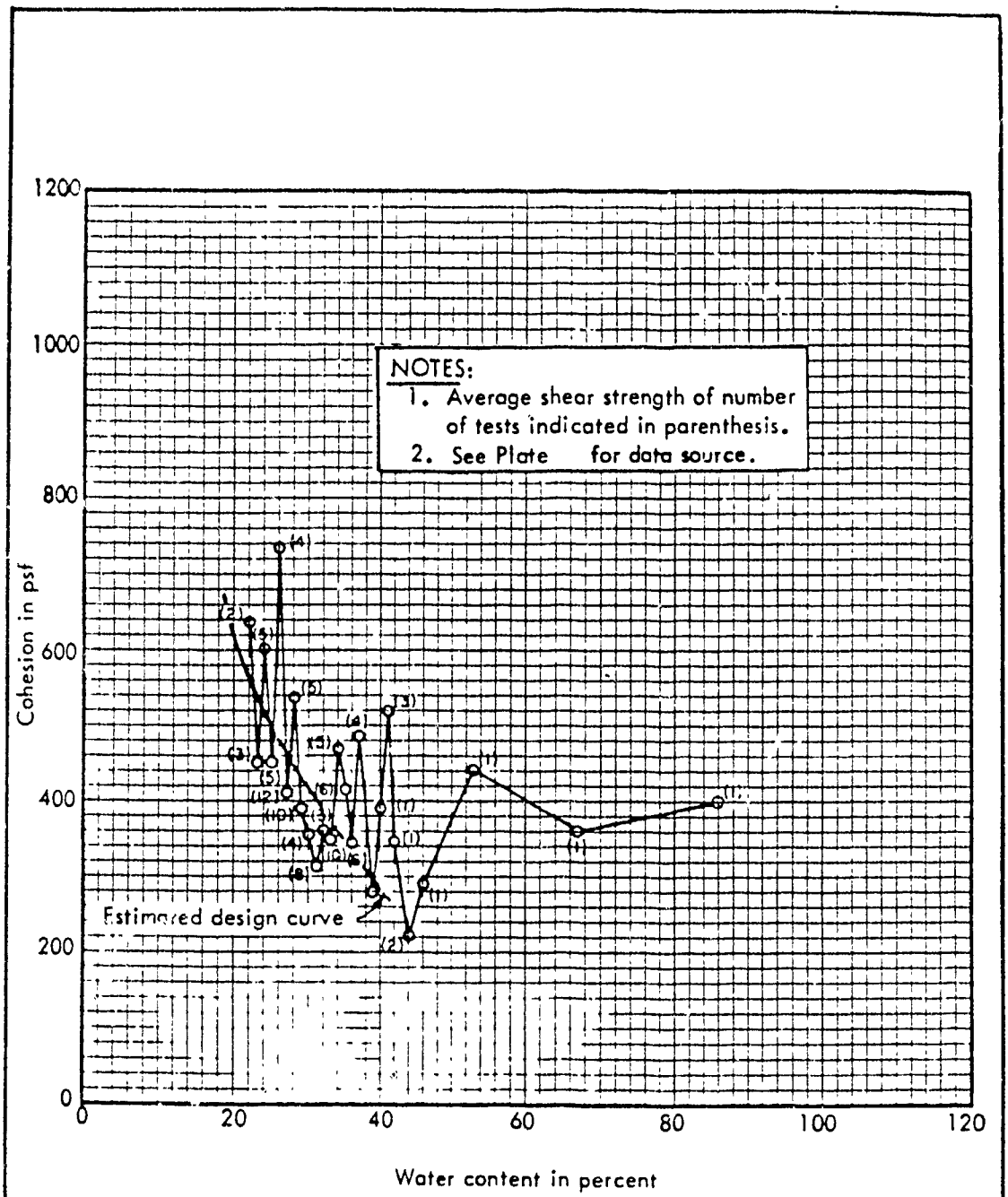
BORING NUMBER		RANGE OF STANDARD PENETRATION BLOWS PER FOOT CAHOKIA SOILS			RANGE OF CONSISTENCY CAHOKIA SOILS		
DESGN.)	SPECIFIED	CL	CL-CH	CH	CL	CL-CH	CH
BLUE 1	WDM-89-53	8-13	----	-----	STIFF	----	-------
RED 2	WDM-89-54	8-10,28	11	-----	SOFT TO STIFF	STIFF	-------
RED 3	WDM-89-55	3-4	10	-----	SOFT	STIFF	-------
BLUE 4A	WDM-89-56	5-12	----	-----	FIRM TO STIFF	----	-------
BLUE 4B	WDM-89-57	6-9	----	-----	FIRM TO STIFF	----	-------
RED 6	WDM-89-58	3-4	----	-----	SOFT	----	-------
RED 5A	WDM-89-59	5-8	----	-----	FIRM	----	-------
RED 12	WDM-89-60	4-15	----	-----	FIRM TO STIFF	----	-------
RED 14	WDM-89-61	-----	----	-----	---------	----	-------
RED 13	WDM-89-62	-----	----	-----	---------	----	-------
RED 15	WDM-89-63	-----	----	-----	---------	----	-------
RED 16	WDM-89-64	-----	----	-----	---------	----	-------
RED 17	WDM-89-65	-----	----	-----	---------	----	-------
BLUE 7	WDM-89-66	2-15	----	-----	V SOFT TO STIFF	----	-------
BLUE 5	WDM-89-67	2-5	9	-----	SOFT TO FIRM	STIFF	-------
RED 20	WDM-89-68	8-12	8	-----	STIFF	FIRM	-------
RED 21	WDM-89-69	13	----	-----	STIFF	----	-------
RED 18	WDM-89-70	4-9	14	-----	FIRM TO STIFF	STIFF	-------
RED 22A	WDM-89-71	-----	----	-----	---------	----	-------
RED 22	WDM-89-72	3-9	----	-----	SOFT TO STIFF	----	-------
BLUE 15	WDM-89-73	7-16	6-7	-----	FIRM TO V STIFF	FIRM	-------
RED 23	WDM-89-74	8	----	-----	FIRM	----	-------

(CONTINUED)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		RANGE OF STANDARD PENETRATION BLOWS PER FOOT CAHOKIA SOILS			RANGE OF CONSISTENCY CAHOKIA SOILS		
DESGNTD	SPECIFIED	CL	CL-CH	CH	CL	CL-CH	CH
RED 24	WDM-89-75	6	----	-----	FIRM	----	-------
RED 25	WDM-89-76	-----	----	-----	---------	----	-------
RED 26	WDM-89-77	4	----	-----	SOFT	----	-------
RED 28	WDM-89-78	4	13	8-15	SOFT	STIFF	STIFF
RED 29	WDM-89-79	10	----	4-5	STIFF	----	FIRM
RED 30	WDM-89-80	-----	----	3-5	---------	----	SOFT TO FIRM
RED 31	WDM-89-81	4-5	----	4-13,55	FIRM	----	FIRM TO STIFF
RED 32	WDM-89-82	4-9	15	-----	FIRM TO STIFF	STIFF	-------
RED 33	WDM-89-83	7	8-9	-----	FIRM	STIFF	-------
RED 34	WDM-89-84	2 WL	11-13	-----	SOFT	STIFF	-------
RED 35	WDM-89-85	12-22	12	-----	STIFF TO V STIF	STIFF	-------
RED 37	WDM-89-86	-----	----	-----	---------	----	-------
RED 38	WDM-89-87	-----	----	-----	---------	----	-------
RED 39	WDM-89-88	-----	----	-----	---------	----	-------
RANGE		(2-16)	(6-15)	(3-15)	(SOFT TO STIFF)	(FIRM TO STIFF)	(SOFT TO STIFF)

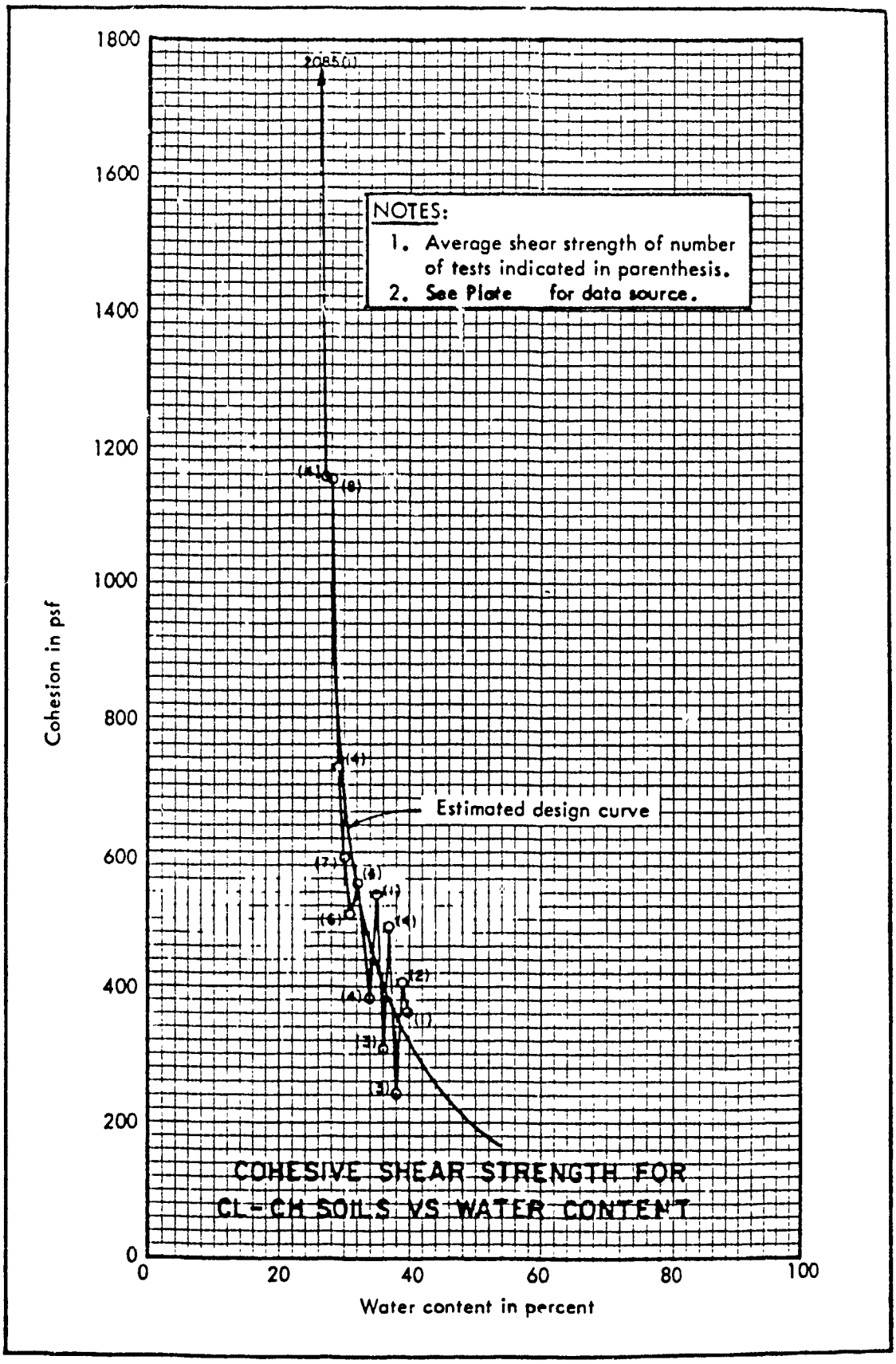
575-006



COHESIVE SHEAR STRENGTH
FOR CL SOILS VS
WATER CONTENT

PLATE C-51

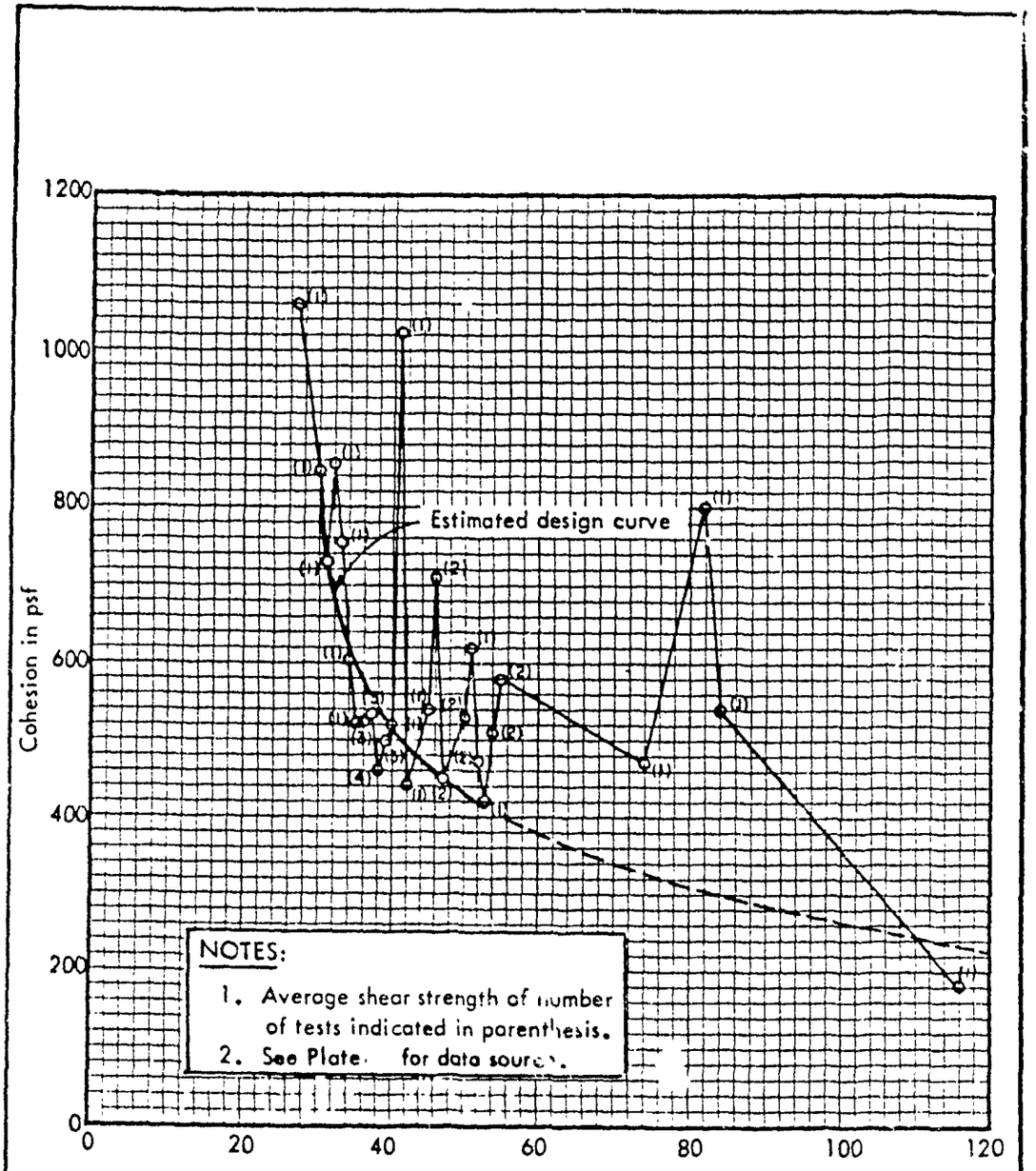
575-006



COHESIVE SHEAR STRENGTH FOR CL-CH SOILS VS WATER CONTENT

PLATE C-52

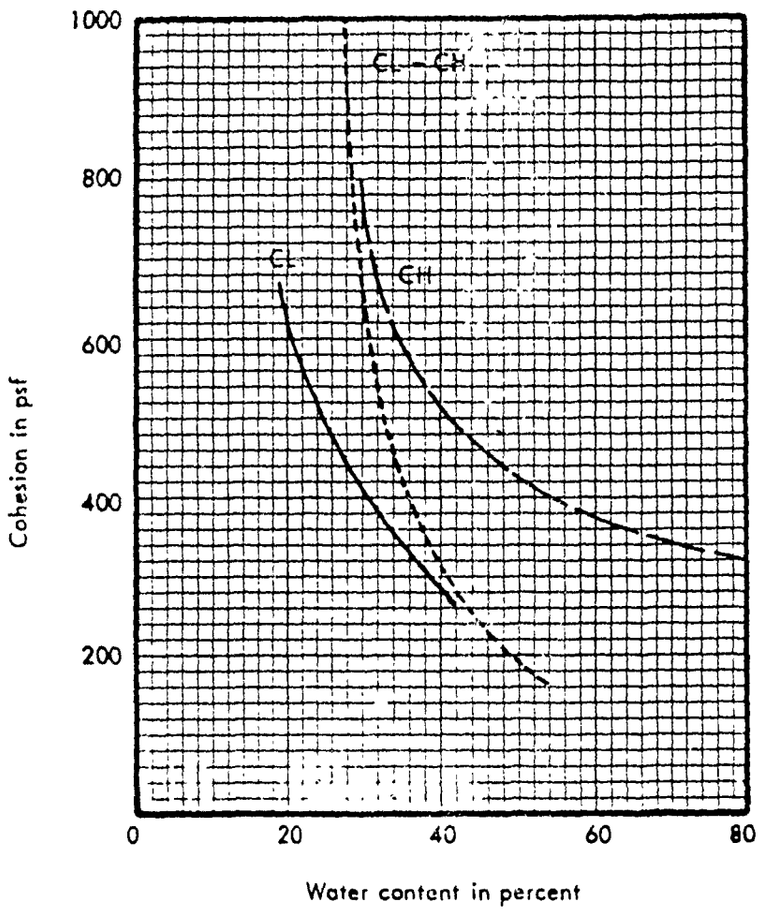
375-006



COHESIVE SHEAR STRENGTH
FOR CH SOILS VS
WATER CONTENT

PLATE C-53

375-026

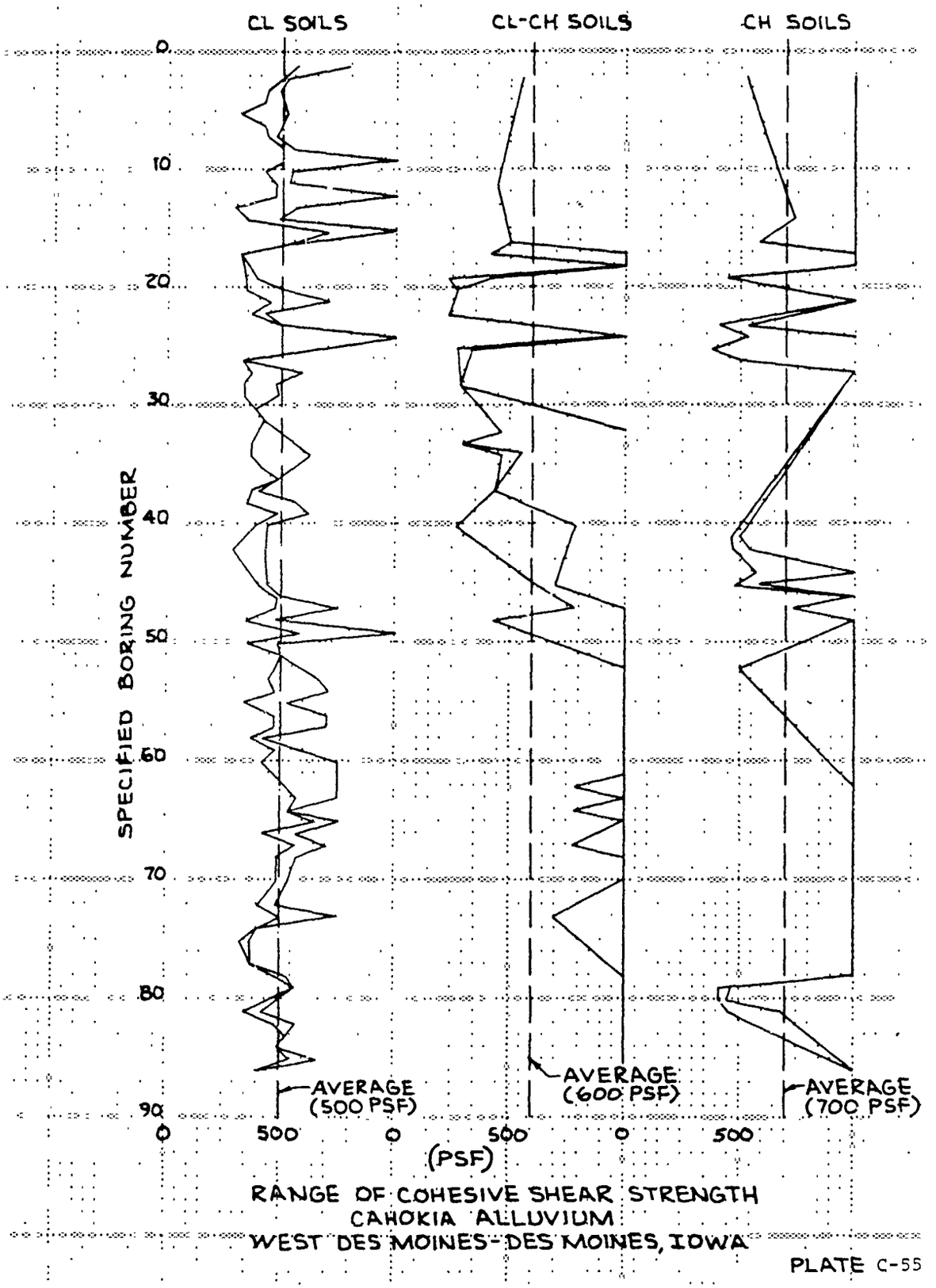


NOTE:

1. Cohesive shear strength curves derived from shear strength data supplied by Rock Island District for Mississippi River alluvial soils in the District, and shown on Plates , ,and .

COHESIVE SHEAR STRENGTH VS WATER CONTENT

PLATE C-54



RANGE OF COHESIVE SHEAR STRENGTH
CAHOKIA ALLUVIUM
WEST DES MOINES-DES MOINES, IOWA

PLATE C-55

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		RANGE OF POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH TONS PER SQUARE FOOT CAHOKIA SOILS			RANGE OF POCKET PENETROMETER CONVERTED COHESIVE SHEAR STRENGTH POUNDS PER SQUARE FOOT CAHOKIA SOILS		
DESGNTD	SPECIFIED	CL	CL-CH	CH	CL	CL-CH	CH
BLUE 1	WDM-89-53	0.75-3.00	-----	-----	750-3000	-----	-----
RED 2	WDM-89-54	0.50-0.75	-----	-----	500-750	-----	-----
RED 3	WDM-89-55	0.25-1.75	0.75	-----	250-1750	750	-----
BLUE 4A	WDM-89-56	0.75-2.75	-----	-----	750-2750	-----	-----
BLUE 4B	WDM-89-57	0.75-2.00	-----	-----	750-2000	-----	-----
RED 6	WDM-89-58	0.25-0.75	-----	-----	250-750	-----	-----
RED 5A	WDM-89-59	0.75-1.25	-----	-----	750-1250	-----	-----
RED 12	WDM-89-60	1.25-2.50	-----	-----	1250-2500	-----	-----
RED 14	WDM-89-61	-----	-----	-----	-----	-----	-----
RED 13	WDM-89-62	-----	-----	-----	-----	-----	-----
RED 15	WDM-89-63	-----	-----	-----	-----	-----	-----
RED 16	WDM-89-64	-----	-----	-----	-----	-----	-----
RED 17	WDM-89-65	-----	-----	-----	-----	-----	-----
BLUE 7	WDM-89-66	0.50-1.25	-----	-----	500-1250	-----	-----
BLUE 5	WDM-89-67	-----	1.75	-----	-----	1750	-----
RED 20	WDM-89-68	0.75-1.50	1.00	-----	750-1500	1000	-----
RED 21	WDM-89-69	-----	-----	-----	-----	-----	-----
RED 18	WDM-89-70	0.25-1.00	-----	-----	250-1000	-----	-----
RED 22A	WDM-89-71	-----	-----	-----	-----	-----	-----
RED 22	WDM-89-72	0.50-1.50	-----	-----	500-1500	-----	-----
BLUE 15	WDM-89-73	1.00	1.00	-----	1000	1000	-----

(CONTINUED)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		RANGE OF POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH TONS PER SQUARE FOOT CAHOKIA SOILS			RANGE OF POCKET PENETROMETER COHESIVE SHEAR STRENGTH POUNDS PER SQUARE FOOT CAHOKIA SOILS		
DESGNTD	SPECIFIED	CL	CL-CH	CH	CL	CL-CH	CH
RED 23	WDM-89-74	-----	-----	-----	-----	-----	-----
RED 24	WDM-89-75	-----	-----	-----	-----	-----	-----
RED 25	WDM-89-76	-----	-----	-----	-----	-----	-----
RED 26	WDM-89-77	-----	-----	-----	-----	-----	-----
RED 28	WDM-89-78	0.75	2.25	1.00-2.75	750	2250	1000-2750
RED 29	WDM-89-79	1.00	-----	0.75	1000	-----	750
RED 30	WDM-89-80	-----	-----	0.25-0.50	-----	-----	250-500
RED 31	WDM-89-81	0.50	-----	1.00-2.25	500	-----	1000-2250
RED 32	WDM-89-82	0.50-1.50	3.00	-----	500-1500	3000	-----
RED 33	WDM-89-83	0.50	1.00-1.25	-----	500	1000-1250	-----
RED 34	WDM-89-84	-----	2.00-2.25	-----	-----	2000-2250	-----
RED 35	WDM-89-85	2.00-4.50	3.00	-----	2000-4500	3000	-----
RED 37	WDM-89-86	-----	-----	-----	-----	-----	-----
RED 38	WDM-89-87	-----	-----	-----	-----	-----	-----
RED 39	WDM-89-88	-----	-----	-----	-----	-----	-----
RANGE		(0.25 - 4.50)	(0.75 - 3.00)	(0.25 - 2.75)	(250 - 3000)	(750 - 3000)	(250 - 2750)

RANGE OF COHESIVE SHEAR STRENGTH
POCKET PENETROMETER VERSUS
MOISTURE CONTENT CORRELATION
WEST DES MOINES - DES MOINES, IOWA

PLATE C-57

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		RANGE OF STANDARD PENETRATION BLOWS / FOOT HENRY SOILS		RANGE OF RELATIVE DENSITY HENRY SOILS	
DESGNTD	SPECIFIED	SP-SC	SP	SP-SC	SP
BLUE 1	WDM-89-53	----	6-8	----------	LOOSE
RED 2	WDM-89-54	----	9-16,63	----------	LOOSE TO MED DENSE
RED 3	WDM-89-55	15-25	28,41	MEDIUM DENSE	MED DENSE TO DENSE
BLUE 4A	WDM-89-56	----	4-11	----------	LOOSE TO MED DENSE
BLUE 4B	WDM-89-57	----	-----	----------	----------
RED 6	WDM-89-58	3-15	8	V LOOSE TO MED DENSE	LOOSE
RED 5A	WDM-89-59	3-5	8-11	V LOOSE TO LOOSE	LOOSE TO MED DENSE
RED 12	WDM-89-60	3	5-8	VERY LOOSE	LOOSE
RED 14	WDM-89-61	----	-----	----------	----------
RED 13	WDM-89-62	----	-----	----------	----------
RED 15	WDM-89-63	----	-----	----------	----------
RED 16	WDM-89-64	----	-----	----------	----------
RED 17	WDM-89-65	----	-----	----------	----------
BLUE 7	WDM-89-66	----	15	----------	MEDIUM DENSE
BLUE 5	WDM-89-67	9-15	4-7	MEDIUM DENSE	LOOSE
RED 20	WDM-89-68	11	-----	MEDIUM DENSE	----------
RED 21	WDM-89-69	6	-----	LOOSE	----------
RED 18	WDM-89-70	8-17	4	LOOSE TO MED DENSE	LOOSE
RED 22A	WDM-89-71	----	-----	----------	----------
RED 22	WDM-89-72	16-18	9-28	MEDIUM DENSE	LOOSE TO MED DENSE
BLUE 15	WDM-89-73	----	5-9	----------	LOOSE

(CONTINUED)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		RANGE OF STANDARD PENETRATION BLOWS / FOOT HENRY SOILS		RANGE OF RELATIVE DENSITY HENRY SOILS	
DESGNTD	SPECIFIED	SP-SC	SP	SP-SC	SP
RED 23	WDM-89-74	----	11	----------	MEDIUM DENSE
RED 24	WDM-89-75	----	5-15	----------	LOOSE TO MED DENSE
RED 25	WDM-89-76	----	9-14	----------	LOOSE TO MED DENSE
RED 26	WDM-89-77	----	4	----------	LOOSE
RED 28	WDM-89-78	----	6-10	----------	LOOSE
RED 29	WDM-89-79	----	16	----------	MEDIUM DENSE
RED 30	WDM-89-80	----	12	----------	MEDIUM DENSE
RED 31	WDM-89-81	----	-----	----------	----------
RED 32	WDM-89-82	4-9	-----	LOOSE	----------
RED 33	WDM-89-83	----	5-16	----------	LOOSE TO MED DENSE
RED 34	WDM-89-84	----	14-24	----------	MEDIUM DENSE
RED 35	WDM-89-85	4-9,61	15-26	LOOSE	MEDIUM DENSE
RED 37	WDM-89-86	----	-----	----------	----------
RED 38	WDM-89-87	----	-----	----------	----------
RED 39	WDM-89-88	----	-----	----------	----------
RANGE		(3-25)	(4-28)	V LOOSE TO MED DENSE	LOOSE TO MED DENSE

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		RANGE OF EFFECTIVE GRAIN SIZE (D_{10}) MILLIMETERS HENRY SOILS		RANGE OF COEFFICIENT OF PERMEABILITY (Kh) CENTIMETERS PER SECOND HENRY SOILS	
DESIGNATD	SPECIFIED	SP-SC	SP	SP-SC	SP
BLUE 1	WDM-89-53	-------	-------	-------	-------
RED 2	WDM-89-54	-------	-------	-------	-------
RED 3	WDM-89-55	0.12-0.16	-------	0.04-0.06	-------
BLUE 4A	WDM-89-56	-------	-------	-------	-------
BLUE 4B	WDM-89-57	-------	-------	-------	-------
RED 6	WDM-89-58	0.17-0.23	0.27	0.07-0.13	0.16
RED 5A	WDM-89-59	-------	-------	-------	-------
RED 12	WDM-89-60	-------	-------	-------	-------
RED 14	WDM-89-61	-------	-------	-------	-------
RED 13	WDM-89-62	-------	-------	-------	-------
RED 15	WDM-89-63	-------	-------	-------	-------
RED 16	WDM-89-64	-------	-------	-------	-------
RED 17	WDM-89-65	-------	-------	-------	-------
BLUE 7	WDM-89-66	-------	-------	-------	-------
BLUE 5	WDM-89-67	0.12-0.30	0.18-0.20	0.04-0.19	0.08-0.10
RED 20	WDM-89-68	-------	-------	-------	-------
RED 21	WDM-89-69	-------	-------	-------	-------
RED 18	WDM-89-70	0.10-0.40	0.18	0.02-0.28	0.08
RED 22A	WDM-89-71	-------	-------	-------	-------
RED 22	WDM-89-72	0.16-0.19	0.22-0.38	0.06-0.09	0.12-0.27
BLUE 15	WDM-89-73	-------	-------	-------	-------

(CONTINUED)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY TESTING

BORING NUMBER		RANGE OF EFFECTIVE GRAIN SIZE (D_{10}) MILLIMETERS HENRY SOILS		RANGE OF COEFFICIENT OF PERMEABILITY (Kh) CENTIMETERS PER SECOND HENRY SOILS	
DESIGNATD	SPECIFIED	SP-SC	SP	SP-SC	SP
RED 23	WDM-89-74	-------	-------	-------	-------
RED 24	WDM-89-75	-------	0.24	-------	0.15
RED 25	WDM-89-76	-------	-------	-------	-------
RED 26	WDM-89-77	-------	-------	-------	-------
RED 28	WDM-89-78	-------	0.34	-------	0.23
RED 29	WDM-89-79	-------	-------	-------	-------
RED 30	WDM-89-80	-------	-------	-------	-------
RED 31	WDM-89-81	-------	-------	-------	-------
RED 32	WDM-89-82	-------	-------	-------	-------
RED 33	WDM-89-83	-------	-------	-------	-------
RED 34	WDM-89-84	-------	-------	-------	-------
RED 35	WDM-89-85	0.16-0.28	0.24-0.27	0.06-0.17	0.14-0.16
RED 37	WDM-89-86	-------	-------	-------	-------
RED 38	WDM-89-87	-------	-------	-------	-------
RED 39	WDM-89-88	-------	-------	-------	-------
RANGE		(0.10-0.40)	(0.18-0.38)	(0.02-0.28)	(0.08-0.27)

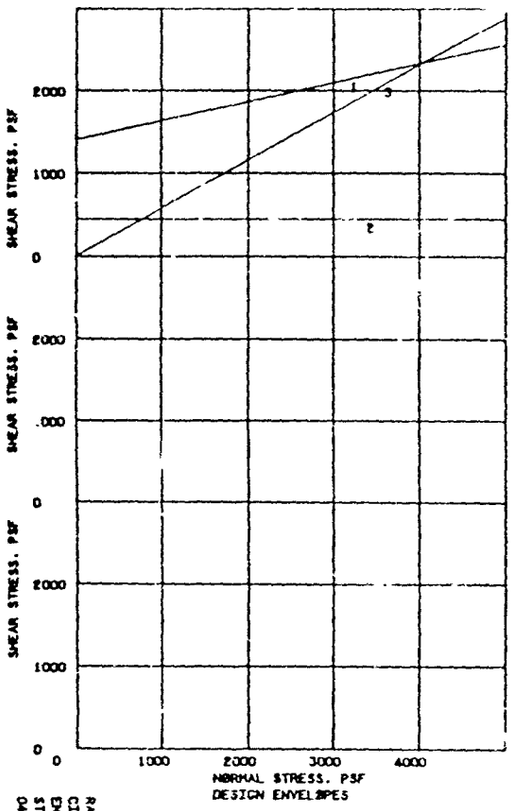
WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY

BORING NUMBER		RANGE OF STANDARD PENETRATION	RANGE OF CONSISTENCY
DESIGNATED	SPECIFIED	BLOWS/FOOT PENN. SHALE BEDROCK	PENNSYLVANIAN SHALE BEDROCK
BLUE 1	WDM-89-53	-------	----------
RED 2	WDM-89-54	65-88	MOD SOFT TO MOD HARD
RED 3	WDM-89-55	83	MODERATELY HARD
BLUE 4A	WDM-89-56	-------	----------
BLUE 4B	WDM-89-57	-------	----------
RED 6	WDM-89-58	89	MODERATELY HARD
RED 5A	WDM-89-59	61	MODERATELY SOFT
RED 12	WDM-89-60	-------	----------
RED 14	WDM-89-61	-------	----------
RED 13	WDM-89-62	-------	----------
RED 15	WDM-89-63	-------	----------
RED 16	WDM-89-64	-------	----------
RED 17	WDM-89-65	-------	----------
BLUE 7	WDM-89-66	-------	----------
BLUE 5	WDM-89-67	112	MODERATELY HARD
RED 20	WDM-89-68	-------	----------
RED 21	WDM-89-69	-------	----------
RED 18	WDM-89-70	97	MODERATELY HARD
RED 22A	WDM-89-71	-------	----------
RED 22	WDM-89-72	97	MODERATELY HARD
BLUE 15	WDM-89-73	-------	----------

(CONTINUED)

WEST DES MOINES - DES MOINES, IOWA
SUMMARY AND EVALUATION OF EXPLORATORY FINDINGS
AND SOILS LABORATORY

BORING NUMBER		RANGE OF STANDARD PENETRATION	RANGE OF CONSISTENCY
DESIGNATED	SPECIFIED	BLOWS/FOOT PENN. SHALE BEDROCK	PENNSYLVANIAN SHALE BEDROCK
RED 23	WDM-89-74	-------	----------
RED 24	WDM-89-75	-------	----------
RED 25	WDM-89-76	-------	----------
RED 26	WDM-89-77	-------	----------
RED 28	WDM-89-78	-------	----------
RED 29	WDM-89-79	51	MODERATELY SOFT
RED 30	WDM-89-80	-------	----------
RED 31	WDM-89-81	55	MODERATELY SOFT
RED 32	WDM-89-82	-------	----------
RED 33	WDM-89-83	-------	----------
RED 34	WDM-89-84	-------	----------
RED 35	WDM-89-85	103	MODERATELY HARD
RED 37	WDM-89-86	-------	----------
RED 38	WDM-89-87	-------	----------
RED 39	WDM-89-88	-------	----------
RANGE		(51-112)	MOD SOFT TO MOD HARD

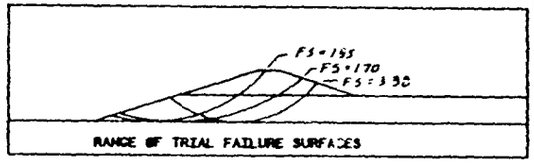


MATERIAL	SOIL WT. LBS./CUFT		SHEAR STRENGTH Q		R		S		(R+S)/2	
	MOIST	SAT.	PHI DEGREES	COHESION PSF	PHI DEGREES	COHESION PSF	PHI DEGREES	COHESION PSF	PHI DEGREES	COHESION PSF
SEMI-COMP IMPR EMB CW EL 807 TO EL 819 1	123.00	125.00	13.00	1400.00	0.00	0.00	0.00	0.00	0.00	0.00
IMPERV TOP STRATUM CL EL 794 TO EL 807 2	114.00	120.00	0.00	450.00	0.00	0.00	0.00	0.00	0.00	0.00
PERV SUBSTRATUM SP EL 759 TO EL 794 3	130.00	135.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

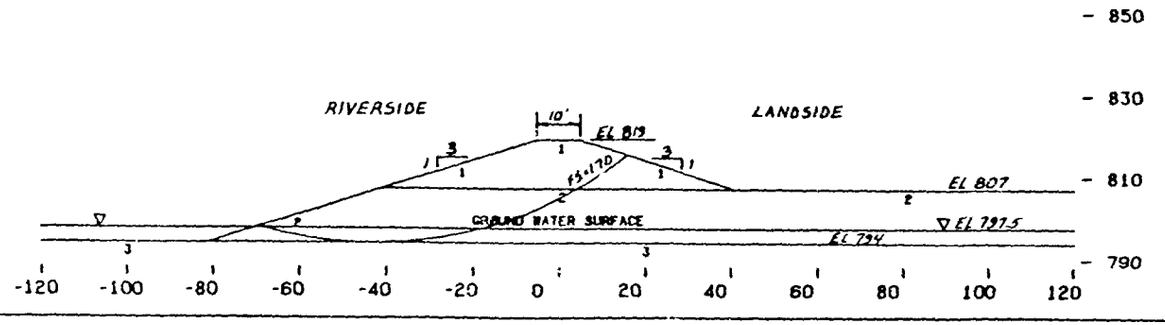
CIRCLE FAILURE SURFACE
RESULTS BY HARRIS-500
COMPUTER PROGRAM 741-H5-F424A
TANGENT TO ELEV 794.00
TRIAL ARCS

RADIUS OF CIRCLE	CENTER OF CIRCLE DISTANCE FROM Q	CENTER OF CIRCLE ELEV	F.S. Q = 0.00	F.S. Q
92.00	-43.00	888.00	1.71	
88.00	-54.00	882.00	1.6	
48.00	-15.00	840.00	3.38	
46.00	-25.00	840.00	2.13	
97.00	-42.00	891.00	1.70	
87.00	-48.00	881.00	1.73	

CRITICAL FAILURE SURFACE



NOTES
1- ANALYSES WERE RUN ACCORDING TO EM 1110-2-1902 DATED APRIL 1970
2- THE SIDE EARTH FORCE DIRECTION WAS TAKEN AS THE AVERAGE OF THE EMBANKMENT SLOPES IMMEDIATELY ADJACENT TO THE SLICE INTERFACE
3- PSI-SIESMIC COEFFICIENT USED IN ANALYSES



RACCOON RIVER, WEST DES MOINES, IOWA
CIRCLE SLOPE STABILITY ANALYSIS
END OF CONSTRUCTION CONDITION
STATION 76+00 RIVERSIDE
04 JUNE 1980 DHB

PLATE C-61

INPUT DATA

MINIMUM ELEVATION OF CIRCLE= 794.0 X-START= -25.0 Y-START= 840.0 SEARCH INCREMENT= 10.0 F.S. MIN.= 0.000

NUMBER OF LINES= 8 MINIMUM NO. OF SLICES= 20 SEISMIC COEFF.= 0.000

EMBANKMENT AND FOUNDATION PROFILE--

XTOEL	YTOEL	XTOPL	YTOPL	XTOER	YTOER	XTOPR	YTOPR
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

X1(I)	Y1(I)	X2(I)	Y2(I)	TYPE
-5000.0	794.0	-81.0	794.0	3
-41.0	807.0	-5.0	819.0	1
-5.0	819.0	5.0	819.0	1
5.0	819.0	41.0	807.0	1
41.0	807.0	5000.0	807.0	2
-41.0	807.0	41.0	807.0	2
-81.0	794.0	5000.0	794.0	3
-81.0	794.0	-41.0	807.0	2

SOIL CONSTANTS--

NUMBER OF SOIL TYPES= 3

TYPE NO.	WT.MOIST	WT.SAT.	C(1)	PHI(1)	C(2)	PHI(2)
1	123.0	125.0	1900.0	13.0	0.0	0.0
2	118.0	120.0	450.0	0.0	0.0	0.0
3	130.0	135.0	0.0	30.0	0.0	0.0

PIEZOMETRIC SURFACE DATA--

NUMBER OF POINTS FOR PIEZOMETRIC SURFACE= 2

XPIEZ(I)	YPIEZ(I)
-5000.0	797.5
5000.0	797.5

DRAWDOWN SURFACE DATA--

NUMBER OF POINTS FOR DRAWDOWN SURFACE= 0

RACCOON RIVER, WEST DES MOINES, IOWA
CIRCLE SLOPE STABILITY ANALYSIS
END OF CONSTRUCTION CONDITION
STATION 78+00 RIVERSIDE
04 JUNE 1990 CHB

PLATE C-62

X-COORDINATE OF CENTER	Y-COORDINATE OF CENTER	FACTOR OF SAFETY
-25.13	840.00	2.128
-25.00	850.00	2.063
-15.00	840.00	2.380
-34.99	841.51	1.880
-44.97	841.03	1.928
-34.47	850.50	1.793
-33.96	860.49	1.763
-33.45	870.47	1.778
-23.37	859.97	2.145
-43.35	861.00	1.750
-53.94	861.51	1.945
-43.44	870.49	1.713
-42.92	881.97	1.720
-42.41	891.96	1.703
-32.39	880.46	1.825
-52.91	881.49	1.824
-47.92	881.23	1.730
-37.93	881.72	1.723
-43.18	875.98	1.704
-42.67	885.97	1.700
-42.41	891.96	1.703
-37.67	885.71	1.739
-47.66	886.22	1.720

****

MINIMUM FACTOR OF SAFETY = 1.700 LOCATED AT X= -42.67 Y= 885.97

NUMBER OF SLICES USED = 26 RADIUS OF CIRCLE = 91.97

****

RACCOON RIVER, WEST DES MOINES, IOWA
CIRCLE SLOPE STABILITY ANALYSIS
END OF CONSTRUCTION CONDITION
STATION 7H+00 RIVERSIDE
04 JUNE 1990 DHH

PLATE C-63

CHECK DATA FOR CRITICAL ARC

FACTOR OF SAFETY= 1.700

LOCATION OF CENTER-- X= -42.67 Y= 685.97

RADIUS= 91.97

TABULATION OF SLICE DATA--

SLICE NO.	X-COORD. OF SLICE	SLICE WIDTH	TOTAL WT.	WATER FORCE	DIR. OF W.FORCE	C-FORCE DEVEL.	PHI DEVEL.	DIR. OF C-FORCE	NORMAL STRESS	NORMAL FORCE	ALPHA TOP	ALPHA BOTM.	E1	E2
1	14.30	3.72	0.97	0.00	0.00	3.90	7.73	38.28	0.16	0.76	0.0	0.0	0.00	0.00
2	10.58	3.72	2.82	0.00	0.00	3.76	7.73	35.38	0.50	2.30	0.0	0.0	0.00	0.00
3	6.86	3.72	4.53	0.00	0.00	3.64	7.73	32.58	0.86	3.82	0.0	0.0	0.00	0.00
4	3.14	0.53	0.77	0.00	0.00	0.51	7.73	31.03	1.07	0.66	0.0	0.0	0.00	0.00
5	2.89	3.16	5.00	0.00	0.00	3.96	0.00	29.70	1.43	5.21	0.0	0.0	0.00	1.75
6	-0.26	3.16	5.64	0.00	0.00	3.94	0.00	27.46	1.65	5.87	0.0	0.0	1.75	3.62
7	-3.42	3.16	6.23	0.00	0.00	0.92	0.00	25.26	1.58	5.53	0.0	9.2	3.62	5.21
8	-7.00	4.00	8.31	0.00	0.00	1.15	0.00	22.82	1.61	6.99	9.2	18.4	5.21	7.16
9	-11.00	4.00	8.49	0.00	0.00	1.13	0.00	20.14	1.86	7.94	18.4	18.4	7.16	8.92
10	-15.00	4.00	8.39	0.00	0.00	1.11	0.00	17.51	1.90	7.98	18.4	18.4	8.92	10.34
11	-19.00	4.00	8.29	0.10	90.00	1.10	0.00	14.91	1.90	7.85	18.4	18.4	10.34	11.35
12	-23.00	4.00	8.09	0.34	90.00	1.08	0.00	12.35	1.83	7.51	18.4	18.4	11.35	11.93
13	-27.00	4.00	7.81	0.54	90.00	1.07	0.00	9.81	1.76	7.15	18.4	18.4	11.93	12.10
14	-31.00	4.00	7.45	0.69	90.00	1.07	0.00	7.29	1.67	6.75	18.4	18.4	12.10	11.88
15	-35.00	4.00	6.99	0.79	90.00	1.06	0.00	4.78	1.57	6.31	18.4	18.4	11.88	11.32
16	-39.00	4.00	6.46	0.86	90.00	1.06	0.00	2.29	1.47	5.86	18.4	18.2	11.32	10.44
17	-41.83	1.66	2.51	0.36	90.00	0.44	0.00	0.52	1.39	2.32	18.2	18.0	10.44	9.98
18	-42.67	0.00	0.00	0.00	90.00	0.00	0.00	0.00	1.34	0.00	18.0	18.0	9.98	9.98
19	-42.67	0.00	0.00	0.00	90.00	0.00	0.00	0.00	1.34	0.00	18.0	18.0	9.98	9.98
20	-44.56	3.77	5.29	0.82	90.00	1.00	0.00	-1.14	1.29	4.85	18.0	18.0	9.98	8.83
21	-44.33	3.77	4.67	1.78	90.00	1.00	0.00	-3.53	1.16	4.37	18.0	18.0	8.83	7.49
22	-52.10	3.77	3.99	0.71	90.00	1.00	0.00	-5.89	1.02	3.85	18.0	18.0	7.49	6.03
23	-55.87	3.77	3.23	0.60	90.00	1.00	0.00	-8.26	0.86	3.29	18.0	18.0	6.03	4.48
24	-59.65	3.77	2.40	0.45	90.00	1.02	0.00	-10.64	0.69	2.67	18.0	18.0	4.48	2.91
25	-63.42	3.77	1.50	0.27	90.00	1.03	0.00	-13.04	0.51	1.98	18.0	18.0	2.91	1.39
26	-67.19	3.77	0.52	0.04	90.00	1.04	0.00	-15.47	0.31	1.23	18.0	9.0	1.39	0.00

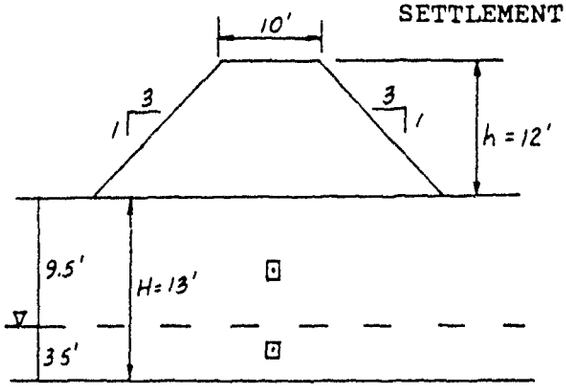
NOTE-ALL ANGLES MEASURED FROM POSITIVE X-AXIS,FORCES ARE IN KIPS

**NOTE HORIZONTAL EARTHQUAKE FORCE MAY BE CALCULATED BY MULTIPLYING THE TOTAL SLICE WT. BY THE E.Q. COEFF.

RACCOON RIVER, WEST DES MOINES, IOWA
CIRCLE SLOPE STABILITY ANALYSIS
END OF CONSTRUCTION CONDITION
STATION 78+00 RIVERSIDE
04 JUNE 1990 DHB

PLATE C-64

WEST DES MOINES - DES MOINES, IOWA
SETTLEMENT ANALYSIS



Levee Embankment
CH soils, γ_m = 123 pcf

Compressible Impervious Top stratum
CL soils, γ_m = 118 pcf,
W_n = 28%, W_L = 41%, G_s = 2.63

CL soils, γ_s = 120 pcf,
W_n = 28%, W_L = 41%, G_s = 2.63

References:

1. "Foundation Analysis and Design, 3rd edition", by Joseph E. Bowles

2. "Boussinesq Coefficient from Tables of Boussinesq Coefficient for Vertical Stress Induction", published by New Orleans District, Corps of Engineers, dated March 1969

Void Ratio, e_o:

$$W_n = \frac{W_w}{W_s} \qquad W_t = W_w + W_s \Rightarrow W_t = W_s + W_n W_s \qquad W_s = \frac{W_t}{1+W_n}$$

$$G_s = \frac{W_s/V_s}{\gamma_w} \Rightarrow V_s = \frac{W_s}{G_s \gamma_w} \qquad V_v = 1 - V_s \qquad e_o = \frac{V_v}{V_s}$$

Compression Index, C_c:

$$C_c = 0.37 (e_o + 0.003 W_L + 0.0004 W_n - 0.34)$$

p_o @ mid-depth = $1/2\ H \cdot \gamma_{m,s}$

Δp = Boussinesq Coefficient $\cdot\ h \cdot \gamma_m$

Settlement, ΔS:

$$\Delta S = \frac{C_c}{1+e_o} H \log_{10} \frac{p_o+\Delta p}{p_o}$$

Total Depth feet	Mid Depth feet	Cc	eo	H feet	po psf	Δp psf	Δs inches
0							
	4.75	0.212	0.779	9.5	280	1449	10.7
9.5							
	11.25	0.201	0.748	3.5	675	1339	2.3
13							
					Total Settlement - - - -		13.0 in.

PLATE C-65

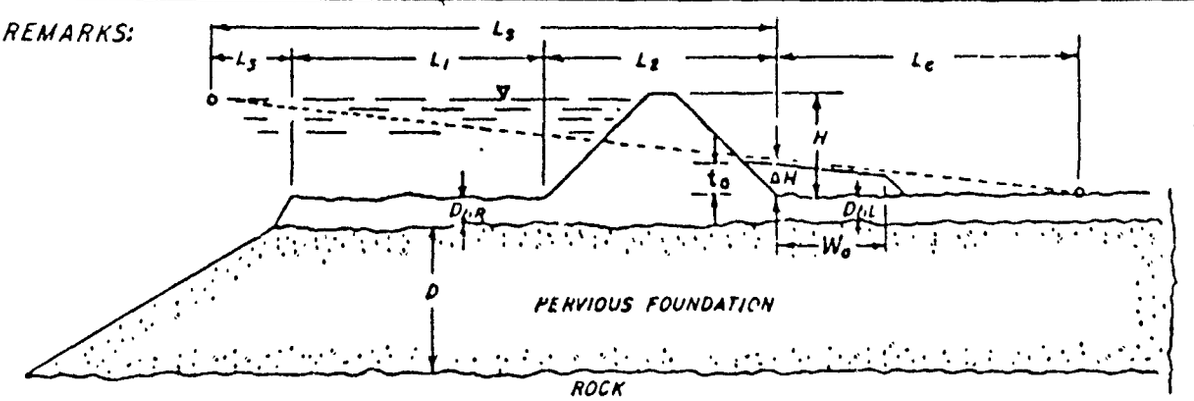
SUMMARY
UNDERSEEPAGE ANALYSIS DATA
BERM ANALYSIS

PROJECT _____ Date _____

Computed by _____ Checked by _____

STATIONS								
LEVEE DESIGN GRADE								
ELEV. L.S. TOE or TAILWATER								
GROSS HEAD	H							
TRANS PERVIOUS FOUNDATION	D							
TRANS. BLANKET THICKNESS L.S.	D_{bL}/D_{bLc}							
TRANS. BLANKET THICKNESS R.S.	D_{bR}							
NAT. BLANKET NGTH L.S.	L_L							
NAT. BLANKET LENGTH R.S.	L_R							
K_f/K_{bL} LANDSIDE	A							
K_f/K_{bR} RIVERSIDE	B							
$C_L = \sqrt{A \cdot D_{bL} \cdot D}$	C_L							
$C_R = \sqrt{B \cdot D_{bR} \cdot D}$	C_R							
$L_1 = C_R \cdot \tanh L_R/C_R$	L_1							
$L_3 = 0.4 \cdot D$	L_3							
L_2 = BASE WIDTH LEVEE	L_2							
$L_S = L_1 + L_2 + L_3$	L_S							
$L_e = C_L\left(\frac{t}{x}\right) \tanh L_L/C_L$	L_e							
$L_S + L_e$								
$\Delta H = H \cdot L_e/L_S + L_e$	ΔH							
F.S. $= 0.85 \, D_{bLc}/\Delta H$	F.S.							
PROBABLE CONTROL								
BERM WIDTH, $W_o = 10H - L_2$	W_o							
COMPUTED $t_o = \frac{94\Delta H - 8 D_{bL} \cdot D_{bLc}}{8 D_{bL} + 94}$	t_o							
SELECTED t	t							

REMARKS:



TRANSFORMED SOIL SECTION

PLATE C-66

UNDERSEEPAGE ANALYSIS

WEST DES MOINES - DES MOINES, IOWA
MAY 1990
DHB

BEGIN STA	0	800	990	2900	3400
END STA	800	940	2900	3400	3920
LEVEE DESIGN GRADE (a)	50	48	48	47	47
L.S. TOE ELEV OR TW (a,b)	44	43	40	39	40
GROSS HEAD	6	5	8	8	7
TRANS. PERVIOUS FDN	35	35	35	10	5
TRANS. BLAN THICKNESS L.S.	9	9	10	9	11
TRANS COVER THICKNESS L.S.	0	0	0	2 (e)	7 (e)
TRANS. BLAN THICKNESS R.S.	9	9	10	8	11
NAT. BLANKET LENGTH L.S.	10000	10000	10000	10000	10000
NAT. BLANKET LENGTH R.S.	200 (c)	300 (c)	1000 (d)	1000 (d)	1200 (d)
K(F)/K(BL) LANDSIDE	200	200	200	200	200
K(F)/K(BR) RIVERSIDE	800	800	800	800	800
CL	251	251	265	134	105
CR	502	502	529	253	210
LR/CR	0.40	0.60	1.89	3.95	5.72
TANH(LR/CR)	0.38	0.54	0.96	1.00	1.00
LL/CL	39.84	39.84	37.80	74.54	95.35
TANH(LL/CL)	1.00	1.00	1.00	1.00	1.00
L1	190	269	506	253	210
L3	15	15	15	4	2
L2	45	40	55	60	50
LS	250	324	576	317	262
LE	251	251	265	134	105
LS+LE	501	575	841	451	367
DELTA H	3.00	2.18	2.36	2.38	2.00
F.S.	2.55	3.51	3.60	3.93	7.64
COMPUTED T(0)	0.00	0.00	0.00	0.00	0.00
CONTROL FLAG	0	0	0	0	0
PROBABLE CONTROL	NONE	NONE	NONE	NONE	NONE
COMPUTED BERM WIDTH	0	0	0	0	0
SELECTED BERM WIDTH	0	0	0	0	0
SELECTED T	0	0	0	0	0
PERM. OF PERVIOUS SUBSTRATUM	0.22	0.22	0.22	0.22	0.22
STATION OF TYPICAL SECTION	800	900	2000	3000	3700

NOTES:

(a) West Des Moines City Datum

(b) Fill landside depressions, ditches, and sloughs with sand to elevation shown for landside toe for a distance of 100 feet beyond the landside toe of levee or berm

(c) Jordan Creek is underseepage entrance

(d) Martin Marietta borrow pits is underseepage entrance

(e) Impervious top stratum overlain with landfill

UNDERSEEPAGE ANALYSIS

WEST DES MOINES - DES MOINES, IOWA
MAY 1990
DHB

BEGIN STA	3950	5100	5800	6800	7200
END STA	5100	5800	6800	7200	7800
LEVEE DESIGN GRADE(a)	47	47	46	46	46
L.S. TOE ELEV OR TW(a,b)	40	38	39	37	35
GROSS HEAD	7	9	7	9	11
TRANS. PERVIOUS FDN	2	10	30	45	45
TRANS. BLAN THICKNESS L.S.	10	14	5	12(g)	14
TRANS COVER THICKNESS L.S.	10(e)	0	8(f)	0	0
TRANS. BLAN THICKNESS R.S.	10	14	13	12	14
NAT. BLANKET LENGTH L.S.	10000	10000	10000	10000	10000
NAT. BLANKET LENGTH R.S.	400(d)	100(d)	400(d)	400(d)	50(d)
K(F)/K(BL) LANDSIDE	200	200	200	200	200
K(F)/K(BR) RIVERSIDE	800	800	800	800	800
CL	63	167	173	329	355
CR	126	335	559	657	710
LR/CR	3.16	0.30	0.72	0.61	0.07
TANH(LR/CR)	1.00	0.29	0.61	0.54	0.07
LL/CL	158.11	59.76	57.74	30.43	28.17
TANH(LL/CL)	1.00	1.00	1.00	1.00	1.00
L1	126	97	343	357	50
L3	1	4	13	20	20
L2	50	60	70	50	75
LS	177	162	426	427	145
LE	63	167	173	329	355
LS+LE	240	329	600	755	500
DELTA H	1.84	4.33	2.02	3.92	7.81
F.S.	9.22	2.75	5.47	2.61	1.52
COMPUTED T(0)	0.00	0.00	0.00	0.00	0.00
CONTROL FLAG	0	0	0	0	0
PROBABLE CONTROL	NONE	NONE	NONE	NONE	NONE
COMPUTED BERM WIDTH	0	0	0	0	0
SELECTED BERM WIDTH	0	0	0	0	0
SELECTED T	0	0	0	0	0
PERM. OF PERVIOUS SUBSTRATUM	0.22	0.22	0.32	0.32	0.32
STATION OF TYPICAL SECTION	4400	5300	6200	7000	7500

NOTES:

(a) West Des Moines City Datum

(b) Fill landside depressions, ditches, and sloughs with sand to elevation shown for landside toe for a distance of 100 feet beyond the landside toe of levee or berm

(d) Martin Marietta borrow pits is underseepage entrance

(e) Impervious top stratum overlain with landfill

(f) Area of rubbish landfill- construct 10 H section or remove rubbish and replace with soil

(g) Area of hardened concrete

UNDERSEEPAGE ANALYSIS

WEST DES MOINES - DES MOINES, IOWA
MAY 1990
DHB

BEGIN STA	7800	8150	8150	8550	9000
END STA	8150	8150	8550	8950	9300
LEVEE DESIGN GRADE (a)	46	46	46	45	45
L.S. TOE ELEV OR TW (a,b)	35	26 (h)	26 (h)	38	39
GROSS HEAD	11	20	20	7	6
TRANS. PERVIOUS FDN	45	45	45	45	35
TRANS. BLAN THICKNESS L.S.	16	8	13	13	21
TRANS COVER THICKNESS L.S.	0	0	0	0	0
TRANS. BLAN THICKNESS R.S.	16	7	13	13	10
NAT. BLANKET LENGTH L.S.	10000	10000	10000	10000	10000
NAT. BLANKET LENGTH R.S.	100 (d)	50 (d)	50 (d)	50 (d)	100 (d)
K(F)/K(BL) LANDSIDE	200	200	200	200	200
K(F)/K(BR) RIVERSIDE	800	800	800	800	800
CL	379	268	342	342	383
CR	759	502	684	684	529
LR/CR	0.13	0.10	0.07	0.07	0.19
TANH(LR/CR)	0.13	0.10	0.07	0.07	0.19
LL/CL	26.35	37.27	29.24	29.24	26.08
TANH(LL/CL)	1.00	1.00	1.00	1.00	1.00
L1	99	50	50	50	99
L3	20	20	20	20	15
L2	75	140 (i)	150 (i)	50	55 (i)
LS	194	210	220	120	169
LE	379	268	342	342	383
LS+LE	574	478	562	462	553
DELTA H	6.95	10.95	11.87	5.19	4.16
F.S.	1.96	0.62	0.93	2.13	4.29
COMPUTED T(0)	0.00	4.10	2.88	0.00	0.00
CONTROL FLAG	0	1	1	0	0
PROBABLE CONTROL	NONE	BERM	BERM	NONE	NONE
COMPUTED BERM WIDTH	0	55	45	0	0
SELECTED BERM WIDTH	0	55	45	0	0
SELECTED T	0	4	3	0	0
PERM. OF PERVIOUS SUBSTRATUM	0.32	0.32	0.32	0.32	0.32
STATION OF TYPICAL SECTION	7900	8150	8400	8700	9200

NOTES:

(a) West Des Moines City Datum

(b) Fill landside depressions, ditches, and sloughs with sand to elevation shown for landside toe for a distance of 100 feet beyond the landside toe of levee or berm

(d) Martin Marietta borrow pits is underseepage entrance

(h) Ponding area - fill to elevation shown for landside toe

(i) Measured base width

UNDERSEEPAGE ANALYSIS

WEST DES MOINES - DES MOINES, IOWA
MAY 1990
DHB

BEGIN STA	9300	10050	10440	10700	11621
END STA	10050	10275	10700	11621	12100
LEVEE DESIGN GRADE(a)	45	44	44	43	42
L.S. TOE ELEV OR TW(a,b)	42	36	36	31	28
GROSS HEAD	3	8	8	12	14
TRANS. PERVIOUS FDN	35	25	25	25	25
TRANS. BLAN THICKNESS L.S.	24	19	11	7	4
TRANS COVER THICKNESS L.S.	0	2	0	0	0
TRANS. BLAN THICKNESS R.S.	16	15	11	7	4
NAT. BLANKET LENGTH L.S.	10000	10000	10000	10000	10000
NAT. BLANKET LENGTH R.S.	300(j)	350(j)	250(j)	175(j)	200(j)
K(F)/K(BL) LANDSIDE	200	200	200	200	100
K(F)/K(BR) RIVERSIDE	800	800	800	800	400
CL	410	308	235	187	100
CR	669	548	469	374	200
LR/CR	0.45	0.64	0.53	0.47	1.00
TANH(LR/CR)	0.42	0.56	0.49	0.44	0.76
LL/CL	24.40	32.44	42.64	53.45	100.00
TANH(LL/CL)	1.00	1.00	1.00	1.00	1.00
L1	281	309	229	163	152
L3	15	11	11	11	11
L2	30	75(i)	55	80	95
LS	327	395	295	254	258
LE	410	308	235	187	100
LS+LE	737	703	529	441	358
DELTA H	1.67	3.51	3.32	5.09	3.91
F.S.	12.22	5.09	2.81	1.17	0.87
COMPUTED T(0)	0.00	0.00	0.00	0.72	1.05
CONTROL FLAG	0	0	0	2	1
PROBABLE CONTROL	NONE	NONE	NONE	NONE	BERM
COMPUTED BERM WIDTH	0	0	0	0	45
SELECTED BERM WIDTH	0	0	0	0	45
SELECTED T	0	0	0	0	3
PERM. OF PERVIOUS SUBSTRATUM	0.28	0.28	0.28	0.28	0.28
STATION OF TYPICAL SECTION	9500	10200	10600	11300	12000

NOTES:

(a) West Des Moines City Datum

(b) Fill landside depressions, ditches, and sloughs with sand to elevation shown for landside toe for a distance of 100 feet beyond the landside toe of levee or berm

(i) Measured base width

(j) Raccoon River is underseepage entrance

UNDERSEEPAGE ANALYSIS

WEST DES MOINES - DES MOINES, IOWA
MAY 1990
DHB

BEGIN STA	12100	12400	13600	14300	14750
END STA	12400	13600	14300	14750	15600
LEVEE DESIGN GRADE(a)	42	42	42	42	43
L.S. TOE ELEV OR TW(a,b)	34	30	32	33	35
GROSS HEAD	8	12	10	9	8
TRANS. PERVIOUS FDN	20	20	20	20	20
TRANS. BLAN THICKNESS L.S.	12	13	12	13	16
TRANS COVER THICKNESS L.S.	0	0	0	0	0
TRANS. BLAN THICKNESS R.S.	12	13	12	17	16
NAT. BLANKET LENGTH L.S.	10000	10000	10000	10000	10000
NAT. BLANKET LENGTH R.S.	500(j)	700(k)	75(k)	50(k)	50(k)
K(F)/K(BL) LANDSIDE	200	200	200	200	200
K(F)/K(BR) RIVERSIDE	800	800	800	800	800
CL	219	228	219	228	253
CR	438	456	438	522	506
LR/CR	1.14	1.53	0.17	0.10	0.10
TANH(LR/CR)	0.81	0.91	0.17	0.10	0.10
LL/CL	45.64	43.85	45.64	43.85	39.53
TANH(LL/CL)	1.00	1.00	1.00	1.00	1.00
L1	357	416	74	50	50
L3	9	9	9	9	9
L2	60	80	70	65	70(i)
LS	426	504	153	124	129
LE	219	228	219	228	253
LS+LE	645	732	372	352	382
DELTA H	2.72	3.74	5.89	5.84	5.30
F.S.	3.75	2.96	1.73	1.89	2.56
COMPUTED T(0)	0.00	0.00	0.00	0.00	0.00
CONTROL FLAG	0	0	0	0	0
PROBABLE CONTROL	NONE	NONE	NONE	NONE	NONE
COMPUTED BERM WIDTH	0	0	0	0	0
SELECTED BERM WIDTH	0	0	0	0	0
SELECTED T	0	0	0	0	0
PERM. OF PERVIOUS SUBSTRATUM	0.28	0.28	0.28	0.28	0.28
STATION OF TYPICAL SECTION	12100	13100	14000	14500	15400

NOTES:

(a) West Des Moines City Datum

(b) Fill landside depressions, ditches, and sloughs with sand to elevation shown for landside toe for a distance of 100 feet beyond the landside toe of levee or berm

(i) Measured base width

(j) Raccoon River is underseepage entrance

(k) Walnut Creek is underseepage entrance

UNDERSEEPAGE ANALYSIS

WEST DES MOINES - DES MOINES, IOWA
MAY 1990
DHB

BEGIN STA	15600		16200		16700		17000		17300	
END STA	16200		16700		17000		17300		17753	
LEVEE DESIGN GRADE (a)	44		45		46		47		48	
L.S. TOE ELEV OR TW (a,b)	35		35		38		42		44	
GROSS HEAD	9		10		8		5		4	
TRANS. PERVIOUS FDN	25		35		35		35		35	
TRANS. BLAN THICKNESS L.S.	14		12		12		15		17	
TRANS COVER THICKNESS L.S.	0		0		0		0		0	
TRANS. BLAN THICKNESS R.S.	13		9		10		10		10	
NAT. BLANKET LENGTH L.S.	10000		10000		10000		10000		10000	
NAT. BLANKET LENGTH R.S.	50	(k)	50	(k)	50	(k)	20	(k)	30	(k)
K(F)/K(BL) LANDSIDE	200		200		200		200		200	
K(F)/K(BR) RIVERSIDE	800		800		800		800		800	
CL	265		290		290		324		345	
CR	510		502		529		529		529	
LR/CR	0.10		0.10		0.09		0.04		0.06	
TANH(LR/CR)	0.10		0.10		0.09		0.04		0.06	
LL/CL	37.80		34.50		34.50		30.86		28.99	
TANH(LL/CL)	1.00		1.00		1.00		1.00		1.00	
L1	50		50		50		20		30	
L3	11		15		15		15		15	
L2	70	(i)	70		65	(i)	35		30	
LS	131		135		130		70		75	
LE	265		290		290		324		345	
LS+LE	395		425		420		394		420	
DELTA H	6.02		4.32		5.17		3.70		2.87	
F.S.	1.98		1.50		1.97		3.45		5.03	
COMPUTED T(0)	0.00		0.02		0.00		0.00		0.00	
CONTROL FLAG	0		2		0		0		0	
PROBABLE CONTROL	NONE		NONE		NONE		NONE		NONE	
COMPUTED BERM WIDTH	0		0		0		0		0	
SELECTED BERM WIDTH	0		0		0		0		0	
SELECTED T	0		0		0		0		0	
PERM. OF PERVIOUS SUBSTRATUM	0.28		0.13		0.13		0.13		0.13	
STATION OF TYPICAL SECTION	15900		16400		16700		17100		17500	

NOTES:

(a) West Des Moines City Datum

(b) Fill landside depressions, ditches, and sloughs with sand to elevation shown for landside toe for a distance of 100 feet beyond the landside toe of levee or berm

(i) Measured base width

(k) Walnut Creek is underseepage entrance

UNDERSEEPAGE ANALYSIS

WEST DES MOINES - DES MOINES, IOWA
MAY 1990
DHB

BEGIN STA	17753 (l)	18495	18950	19271	19518
END STA	18430	18940	19271	19518 (m)	20400
LEVEE DESIGN GRADE (a)	49	51	51	52	53
L.S. TOE ELEV OR TW (a,b)	45	45	46	43	41
GROSS HEAD	4	6	5	9	12
TRANS. PERVIOUS FDN	30	20	10	10	25
TRANS. BLAN THICKNESS L.S.	14	14	15	12	9
TRANS COVER THICKNESS L.S.	0	0	0	0	0
TRANS. BLAN THICKNESS R.S.	14	9	10	12	8
NAT. BLANKET LENGTH L.S.	10000	10000	10000	10000	10000
NAT. BLANKET LENGTH R.S.	35 (k)	250 (k)	250 (k)	250 (k)	200 (k)
K(F)/K(BL) LANDSIDE	200	200	200	200	200
K(F)/K(BR) RIVERSIDE	800	800	800	800	800
CL	290	237	173	155	212
CR	580	379	283	310	400
LR/CR	0.06	0.66	0.88	0.81	0.50
TANH(LR/CR)	0.06	0.58	0.71	0.67	0.46
LL/CL	34.50	42.26	57.74	64.55	47.14
TANH(LL/CL)	1.00	1.00	1.00	1.00	1.00
L1	35	219	200	207	185
L3	13	9	4	4	11
L2	1	1	1	1	80
LS	49	229	206	212	276
LE	290	237	173	155	212
LS+LE	339	466	379	367	488
DELTA H	3.42	2.80	2.29	3.59	5.00
F.S.	3.48	4.26	5.58	2.84	1.53
COMPUTED T(0)	0.00	0.00	0.00	0.00	0.00
CONTROL FLAG	0	0	0	0	0
PROBABLE CONTROL	NONE	NONE	NONE	NONE	NONE
COMPUTED BERM WIDTH	0	0	0	0	0
SELECTED BERM WIDTH	0	0	0	0	0
SELECTED T	0	0	0	0	0
PERM. OF PERVIOUS SUBSTRATUM	0.18	0.18	0.18	0.18	0.15
STATION OF TYPICAL SECTION	18000	18600	19100	19400	19900

NOTES:

(a) Wes Des Moines City Datum

(b) Fill landside depressions, ditches, and sloughs with sand to elevation shown for landside toe for a distance of 100 feet beyond the landside toe of levee or berm

(k) Walnut Creek is underseepage entrance

(l) Begin I-wall

(m) End I-wall

UNDERSEEPAGE ANALYSIS

WEST DES MOINES - DES MOINES, IOWA
MAY 1990
DHB

BEGIN STA	20400	21100	21825	22000
END STA	21100	21825	21970	22400
LEVEE DESIGN GRADE (a)	54	55	55	55
L.S. TOE ELEV OR TW (a,b)	44	44	45	50
GROSS HEAD	10	11	10	5
TRANS. PERVIOUS FDN	25	25	25	25
TRANS. BLAN THICKNESS L.S.	11	11	17	14
TRANS COVER THICKNESS L.S.	0	3	3	0
TRANS. BLAN THICKNESS R.S.	11	10	8	14
NAT. BLANKET LENGTH L.S.	10000	10000	10000	10000
NAT. BLANKET LENGTH R.S.	100 (k)	200 (k)	600 (k)	1000 (k)
K(F)/K(BL) LANDSIDE	200	200	200	200
K(F)/K(BR) RIVERSIDE	800	800	800	800
CL	235	235	292	265
CR	469	447	400	529
LR/CR	0.21	0.45	1.50	1.89
TANH(LR/CR)	0.21	0.42	0.91	0.96
LL/CL	42.64	42.64	34.30	37.80
TANH(LL/CL)	1.00	1.00	1.00	1.00
L1	99	188	362	506
L3	11	11	11	11
L2	65	75	65	35
LS	175	274	438	552
LE	235	235	292	265
LS+LE	409	508	730	816
DELTA H	5.45	4.85	3.80	1.46
F.S.	1.72	2.46	4.48	8.16
COMPUTED T(0)	0.00	0.00	0.00	0.00
CONTROL FLAG	0	0	0	0
PROBABLE CONTROL	NONE	NONE	NONE	NONE
COMPUTED BERM WIDTH	0	0	0	0
SELECTED BERM WIDTH	0	0	0	0
SELECTED T	0	0	0	0
PERM. OF PERVIOUS SUBSTRATUM	0.15	0.15	0.15	0.15
STATION OF TYPICAL SECTION	20900	21500	21900	22200

NOTES:

(a) West Des Moines City Datum

(b) Fill landside depressions, ditches, and sloughs with sand to elevation shown for landside toe for a distance of 100 feet beyond the landside toe of levee or berm

(k) Walnut Creek is underseepage entrance

WEST DES MOINES - DES MOINES, IOWA
MAY 1990

REMARKS

LEVEE CONFIGURATION

Station 0+00 to 81+50, 1V on 3H riverside and landside slopes, 10' crown width, no berm

Station 81+50 to 85+50, 1V on 3H riverside and landside slopes, 10' crown width, with berm

Station 85+50 to 116+21, 1V on 3H riverside and landside slopes, 10' crown width, no berm

Station 116+21 to 121+00, 1V on 3H riverside and landside slopes, 10' crown width, with berm

Station 121+00 to 170+00, 1V on 3H riverside and landside slopes, 10' crown width, no berm

Station 170+00 to 177+53, 1V on 2.5H riverside and landside slope, 10' crown width, no berm

Station 177+53 to 195+18, I-Wall, no berm

Station 195+18 to 224+00, 1V on 3H riverside and landside slopes, 10' crown width, no berm

STRUCTURE

Station 9+40 to 9+90, Closure - sand bag - Chicago and Northwestern Railroad

Station 39+20 to 39+50, Closure - spur track - Chicago and Northwestern Railroad

Station 58+00, Gatewell

Station 68+00, Gatewell

Station 81+50, Pump Station - Johnny's Vet Club

Station 89+50 to 90+00, Closure - sand bag - 63rd street

Station 100+50, Gatewell

Station 102+75 to 104+40, Closure - double track - Chicago and Northwestern Railroad

Station 116+21, Gatewell

Station 143+00, Gatewell

Station 147+00, Gatewell at Valley Drive

Station 184+30 to 184+95, Closure - Grand Avenue Bridge

Station 189+40 to 189+50, Closure - Norfolk and Southern Railroad

Station 192+71, Closure - SW 63rd Street

Station 218+25, Closure - Wheeler Lumber

Station 219+70 to 220+20, Closure - double track - Norfolk and Southern Railroad

Transformation of Pervious Foundation		Date 20 FEB 90
J. R. K.	Checked by	Sheet

WEST DES MOINES - DES MOINES, IOWA

USCS Symbol	Elevation	D10 mm	ΔD' ft	kh cm/sec	ΔD'kh ft. cm/sec	kh/kv	kv cm/sec	ΔD'/kv
Boring WDM-89-55 Station 215								
CL-CH, CL	818 - 807	Medium clay and lean clay top stratum						
SP	807 - 805	Isolated sand layer top stratum						
CL	805 - 804	Sandy lean clay top stratum						
SC	804 - 795	Clayey sand and gravelly clayey sand substratum						
SP-SC	795 - 787	0.12	8	0.04	0.32	1	0.040	200
SW-SC	787 - 785	0.16	2	0.06	0.12	1	0.060	33
SP	785 - 775	(0.27)	10	0.16	1.60	2	0.080	125
SH	775 - 772	Pennsylvanian shale bedrock						
					2.04			358

$$D = \sqrt{D'kh \times D'/kv} = \sqrt{2.04 \times 358} = \underline{27 \text{ feet}}$$

$$kf = \sqrt{\frac{\Delta D'kh}{\Delta D'/kv}} = \sqrt{\frac{2.04}{358}} = \underline{0.08 \text{ cm/sec}} = \underline{0.15 \text{ ft/min}}$$

NCR Form 3811

PLATE C-76

Subject		Date
Transformation of Pervious Foundation		20 FEB 90
Computed by L.N.E.	Checked by	Sheet of

WEST DES MOINES - DES MOINES, IOWA

USCS Symbol	Elevation	D10 mm	ΔD' ft	kh cm/sec	ΔD'kh ft cm/sec	kh/kv	kv cm/sec	ΔD'/kv
	Boring WDM-89-58 Station 186							
CL	814 - 802	Sandy lean and lean clay top stratum						
SP-SC	802 - 799	0.17	3	0.07	0.21	1	0.070	43
SP-SC	799 - 796	0.23	3	0.13	0.39	1	0.130	23
SP-SC	796 - 786	0.19	10	0.09	0.90	1	0.090	111
SP	786 - 781	0.27	5	0.16	0.80	2	0.080	63
SP-SC	781 - 776	0.17	5	0.07	0.35	1	0.070	71
CL	776 - 773	Sandy lean clay substratum						
SH	773 - 771	Pennsylvanian shale bedrock						
					2.65			311

$$D = \sqrt{D'kh \times D'/kv} = \sqrt{2.65 \times 311} = 29 \text{ feet}$$

$$kf = \sqrt{\frac{\Delta D'kh}{\Delta D'/kv}} = \sqrt{\frac{2.65}{311}} = 0.09 \text{ cm/sec} = 0.18 \text{ ft/min}$$

	Transformation of Pervious Foundation	
	CNC	

WEST DES MOINES - DES MOINES, IOWA

USCS Symbol	Elevation	D10 mm	ΔD' ft	kh cm/sec	ΔD'kh ft cm/sec	kh/kv	kv cm/sec	ΔD'/kv
	Boring WDM-99-67 Station 167							
CL-CH	810 - 805	Medium clay top stratum						
CL	805 - 800	Sandy lean clay with thin layers of sand top stratum						
SP	800 - 797	0.20	3	0.10	0.30	2	0.050	60
SP-SC	797 - 791	0.30	6	0.19	1.14	1	0.190	32
SC-SC	791 - 780	0.12	11	0.04	0.44	1	0.040	275
SP	780 - 776	0.18	4	0.08	0.32	3	0.027	148
SC	776 - 770	Clayey sand substratum						
CL	770 - 766	Sandy lean clay substratum						
SH	766 - 764	Pennsylvanian shale bedrock						
					2.20			515

$$D = \sqrt{D'kh \times D'/kv} = \sqrt{2.20 \times 515} = 34 \text{ feet}$$

$$kf = \sqrt{\frac{\Delta D'kh}{\Delta D'/kv}} = \sqrt{\frac{2.20}{515}} = 0.07 \text{ cm/sec} = 0.13 \text{ ft/min}$$

	Transformation of Pervious Foundation	Date: 21 FEB 90
Computed by: D.T.E	Checked by:	Sheet: of

WEST DES MOINES - DES MOINES, IOWA

USCS Symbol	Elevation	D10 mm	ΔD' ft	kh cm/sec	ΔD'kh ft cm/sec	kh/kv	kv cm/sec	ΔD'/kv
	Boring WDM-89-70 Station 101							
CL, CL-CH	813 - 798	Sandy lean clay, medium clay, and lean clay top stratum						
SP	798 - 796	(0.22)	2	0.12	0.24	2	0.060	33
SP	796 - 794	0.18	2	0.08	0.16	3	0.027	74
SW-SC	794 - 789	0.26	5	0.15	0.75	1	0.150	33
SP-SC	789 - 784	0.40	5	0.28	1.40	1	0.280	18
SP-SC	784 - 778	0.30	6	0.19	1.14	1	0.190	32
SC	778 - 774	Clayey sand, trace wood substratum						
SP-SC	774 - 770	0.10	4	0.02	NA	1	0.02	NA
CH	770 - 766	Pennsylvanian shale bedrock						
					3.69			190

$$D = \sqrt{D'kh \times D'/kv} = \sqrt{3.69 \times 190} = 26 \text{ feet}$$

$$kf = \sqrt{\frac{\Delta D'kh}{\Delta D'/kv}} = \sqrt{\frac{3.69}{190}} = 0.14 \text{ cm/sec} = 0.28 \text{ ft/min}$$

Transformation of Pervious Foundation		Date 01 FEB 90
[illegible] G.H.T.	Check [illegible]	Sheet [illegible]

WEST DES MOINES - DES MOINES, IOWA

USCS Symbol	Elevation	D10 mm	ΔD' ft	kh cm/sec	ΔD'kh ft cm/sec	kh/kv	kv cm/sec	ΔD'/kv
	Boring WDM-89-72 Station 78							
CL	807 - 794	Lean clay and sandy lean clay top stratum						
SP-SC	794 - 793	0.19	1	0.09	0.09	1	0.090	11
SW-SC	793 - 789	0.16	4	0.06	0.24	1	0.060	67
SP	789 - 785	0.38	4	0.27	1.08	1	0.270	15
SC	785 - 779	0.22	6	0.12	0.72	2	0.060	100
SP	779 - 774	(0.37)	5	0.26	1.30	1	0.260	19
SP	774 - 769	(0.34)	5	0.23	1.15	1	0.230	22
SP	769 - 759	0.36	10	0.25	2.50	1	0.250	40
SH	759 - 757	Pennsylvanian shale bedrock						
					7.08			274

$$D = \sqrt{D'kh \times D'/kv} = \sqrt{7.08 \times 274} = 44 \text{ feet}$$

$$kf = \sqrt{\frac{\Delta D'kh}{\Delta D'/kv}} = \sqrt{\frac{7.08}{274}} = 0.16 \text{ cm/sec} = 0.32 \text{ ft/min}$$

NCR Form [illegible]
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PLATE C-80

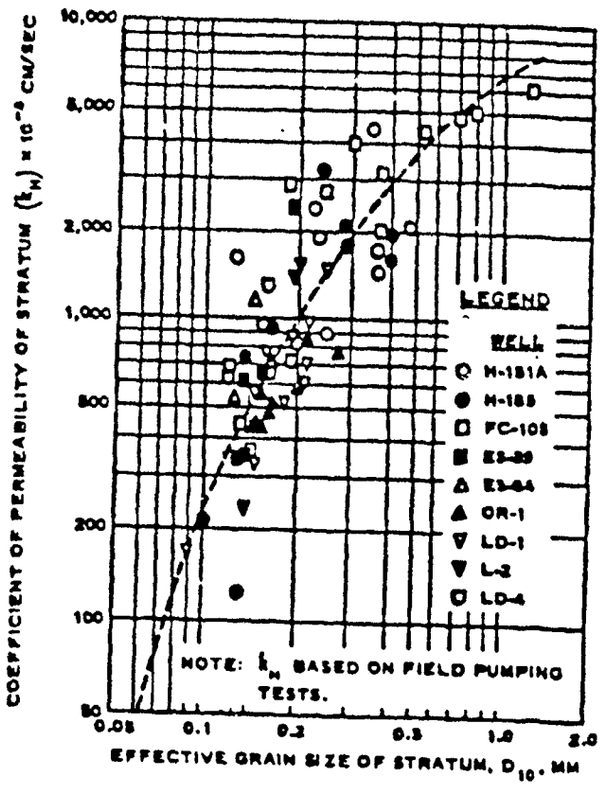
Subject: Transformation of Pervious Foundation		Date: 21 FEB 90
Computed By: C.L.E.	Checked By:	Sheet: of

WEST DES MOINES - DES MOINES, IOWA

USCS Symbol	Elevation	D10 mm	ΔD' ft	kh cm/sec	ΔD'kh ft cm/sec	kh/kv	kv cm/sec	ΔD'/kv
Boring WOM-89-85 Station 13								
CL, CL-CH	815 - 805	Sandy lean clay, medium clay, and lean clay top stratum						
SP-SC	805 - 803	(0.19)	2	0.09	0.18	1	0.090	22
SP-SC	803 - 791	0.28	12	0.17	2.04	1	0.170	71
SP	791 - 787	0.24	4	0.14	0.56	2	0.070	57
SP	787 - 783	0.27	4	0.16	0.64	2	0.080	50
SP-SC	783 - 775	0.16	8	0.06	0.48	1	0.060	133
SH	775 - 774	Pennsylvanian shale bedrock						
					3.90			333

$$D = \sqrt{D'kh \times D'/kv} = \sqrt{3.90 \times 333} = 36 \text{ feet}$$

$$kf = \sqrt{\frac{\Delta D'kh}{\Delta D'/kv}} = \sqrt{\frac{3.90}{333}} = 0.11 \text{ cm/sec} = 0.22 \text{ ft/min}$$



(b) Effective grain size, D_{10}, versus coefficient of permeability, k_H (from WES TM No. 3-424, ref. A-3b(2)

PLATE C-82

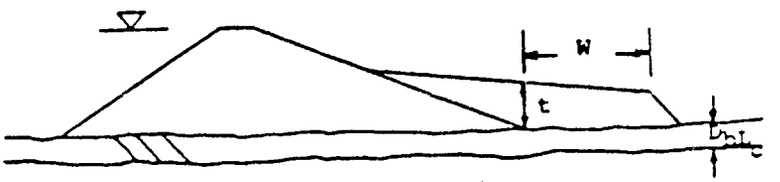
30 April 1976

A Method to Estimate the Thickness and Width of Sand Berms for Sand Levees

		Notes*	Stations
	Elev. top of levee		
	Elev. landside toe (tailwater)		
H	Gross head		
L_2	Base width of levee	(a)	
W_o	$10H - L_2$	(b)	
D	Trans. thickness perv. found.	(c)	
L_L	Landside blanket - width	(d)	
D_{bL}	- thickness	(e)	
D_{bL_c}	- cover	(f)	
A	- perm. ratio	(g)	
C_L	$\sqrt{A \cdot D_{bL} \cdot D}$		
L_R	Riverside blanket - width	(h)	
D_{bR}	- thickness	(i)	
B	- perm. ratio	(j)	
C_R	$\sqrt{B \cdot D_{bR} \cdot D}$		
L_3	Entrance: $0.44D$	(k)	
$L_{1(o)}$	Riverside: $C_R \cdot (\tanh L_R/C_R)$ (or)	(l)	
$L_{1(x)}$	$C_R/(\tanh L_R/C_R)$	(m)	
$L_{e(o)}$	Landside: $C_L \cdot (\tanh L_L/C_L)$ (or)	(n)	
$L_{e(x)}$	$C_L/(\tanh L_L/C_L)$	(o)	
$L_s + L_e$	Total: $L_2 + L_3 + L_1 + L_e$		
ΔH	$H \cdot L_e/(L_s + L_e)$		
F.S.	$(\gamma_{bL} \cdot D_{bL_c})/(\Delta H \cdot \gamma_W)$	(p)	
t_o	$(1.5\gamma_W \cdot \Delta H - D_{bL_c} \cdot \gamma_{bL})/(1.5\gamma_W + \gamma_{bL})$	(q)	
Probable Control		(r)	
t	Selected berm thickness	(s)	
W	Selected berm width	(t)	

All dimensions in feet.

*Notes on separate sheet.

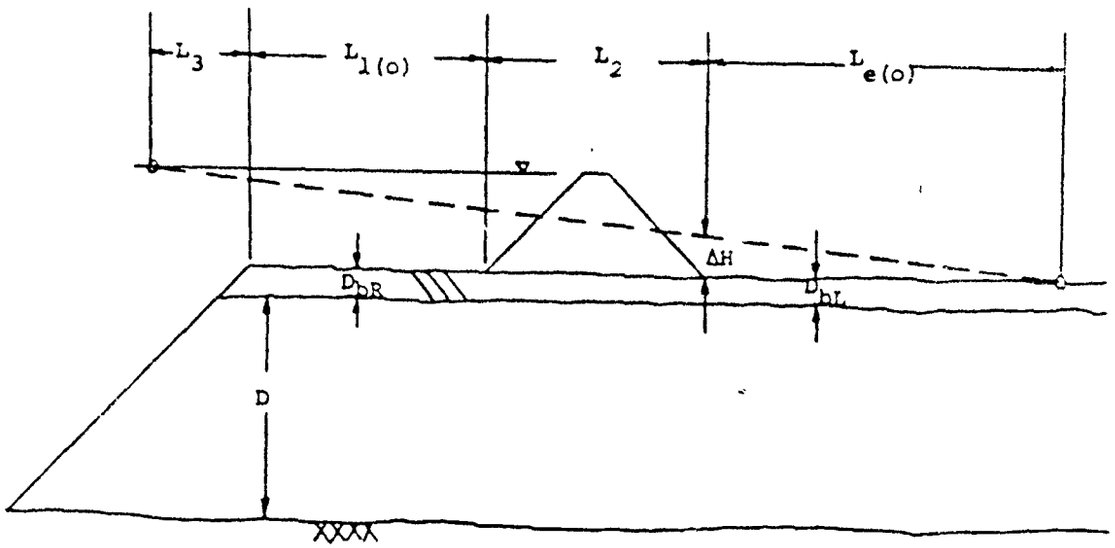


Sketch of levee and foundation configurations on separate sheet.

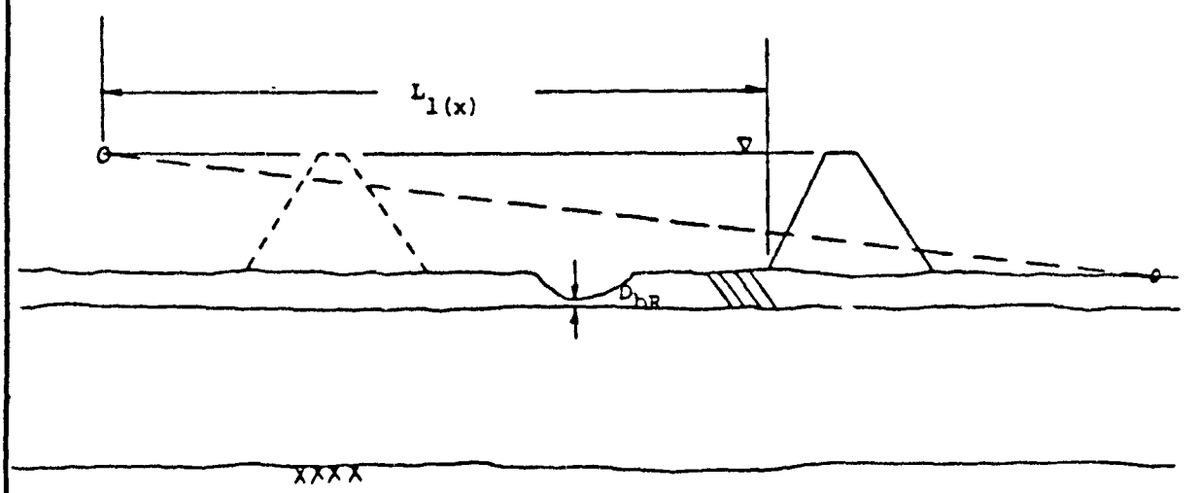
PLATE C-83

30 April 1976

A Method to Estimate the Thickness and Width
of Sand Berms for Sand Levees



Open entrance - Infinite L.S. blanket



Blocked entrance - Infinite L.S. blanket

TRANSFORMED SECTIONS

PLATE C-84

30 April 1976

A Method to Estimate the Thickness and Width
of Sand Berms for Sand Levees

Notes:

(a) Measured from cross section at elev. of landside toe.

(b) Computed berm width. If base width equals or exceeds 10H no berm required.

(c) Procedure and computation on separate sheets.

(d) If L_L is less than 100 ft. provide berm and/or fill depressions to elev. of landside toe for a distance of 100 ft. beyond toe of levee or berm.

(e) If D_{bL} is zero provide berm as for (d). Transformed thickness if blanket includes semipervious soils. Use 0.5 of natural thickness for ML, 0.1 for SM, 0.0 for sand and 1.0 for impervious.

(f) Transformed thickness as for (e) except, when impervious blanket is overlain with pervious or semipervious soils, then the natural total thickness is used for the overlying soils.

(g) For D_{bL} equal to or less than 4, A = 100: for D_{bL} equal to or greater than 5, A = 200, = K_f/K_{bL}.

(h) For parallel diversion levees with blocked entrance, use 1/2 distance between riverside toes of levees.

(i) Transformed thickness as for (e).

(j) For D_{bR} equal to or less than 4, B = 400: for D_{bR} equal to or greater than 5, B = 800, = K_f/K_{bR}.

(k) For parallel diversion levees with clay in thalweg, use L_3 = 0.

(l) Use $L_{1(o)}$ for an open (o) entrance.

(m) Use $L_{1(x)}$ for blocked (x) entrance.

(n) Use $L_{e(o)}$ for finite open (o) exit or infinite blanket.

(o) Use $L_{e(x)}$ for blocked (x) exit.

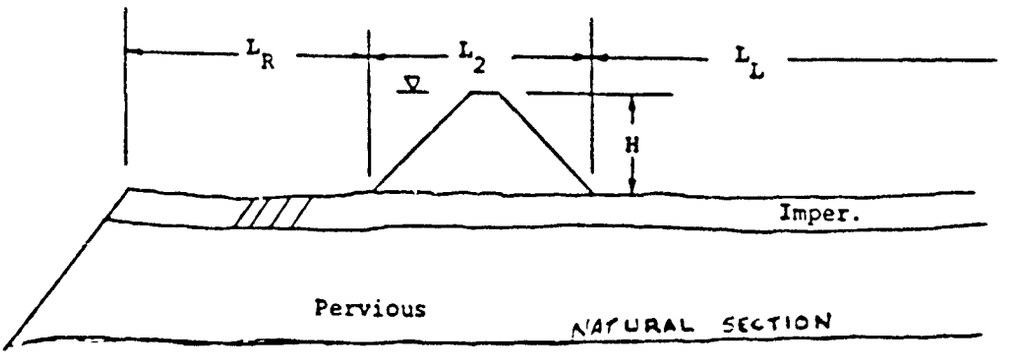
(p) γ_{bL} is submerged unit weight of landside blanket cover and berm (use 53 p.c.f.). γ_w is 62.4 p.c.f.

(q) Computed berm thickness for a factor of safety of 1.5 at landside toe of levee.

(r) For factor of safety computed at the landside toe of the levee, a berm is not required if F.S. greater than 1.5. Berm required if F.S. is equal to or less than 1.0. If F.S. greater than 1.0 and less than 1.5, and if computed berm thickness (q) is greater than 2.0, berm required. If F.S. greater than 1.0 and less than 1.5, and if computed berm thickness (q) is less than 2.0, judgment will determine whether a berm is required.

(s) Minimum 3.0 ft.

(t) Minimum 10 ft.



NATURAL SECTION

PLATE C-85

30 April 1976

Procedure for Transformation of Pervious Foundation

$$D = \sqrt{\Sigma(d_{(n)}K_{h(n)})\ \Sigma\ (d_{(n)}/K_{v(n)})}$$

$$K_f = \sqrt{\Sigma(d_{(n)}K_{h(n)})/\Sigma\ (d_{(n)}/K_{v(n)})}$$

where

$d\ (1,2,3....n)$ = increment $(1,2,3....n)$ of depth of pervious strata

$K_h\ (1,2,3....n)$ = horizontal permeability for corresponding increment $(1,2,3....n)$ of pervious strata*

$K_v\ (1,2,3....n)$ = vertical permeability for corresponding increment $(1,2,3....n)$ of pervious strata

$K_h\ (1,2,3....n)/K_v\ (1,2,3....n)$ = 1 if $D_{10} > 0.30$

= 2 if $0.20 < D_{10} \leq 0.30$

= 3 if $D_{10} < 0.20$

*The value of K_h is estimated from the D_{10} size and the graph shown in Transactions of A.S.C.E., Vol. 126, 1961, Part 1, p. 1449, Figure 12.

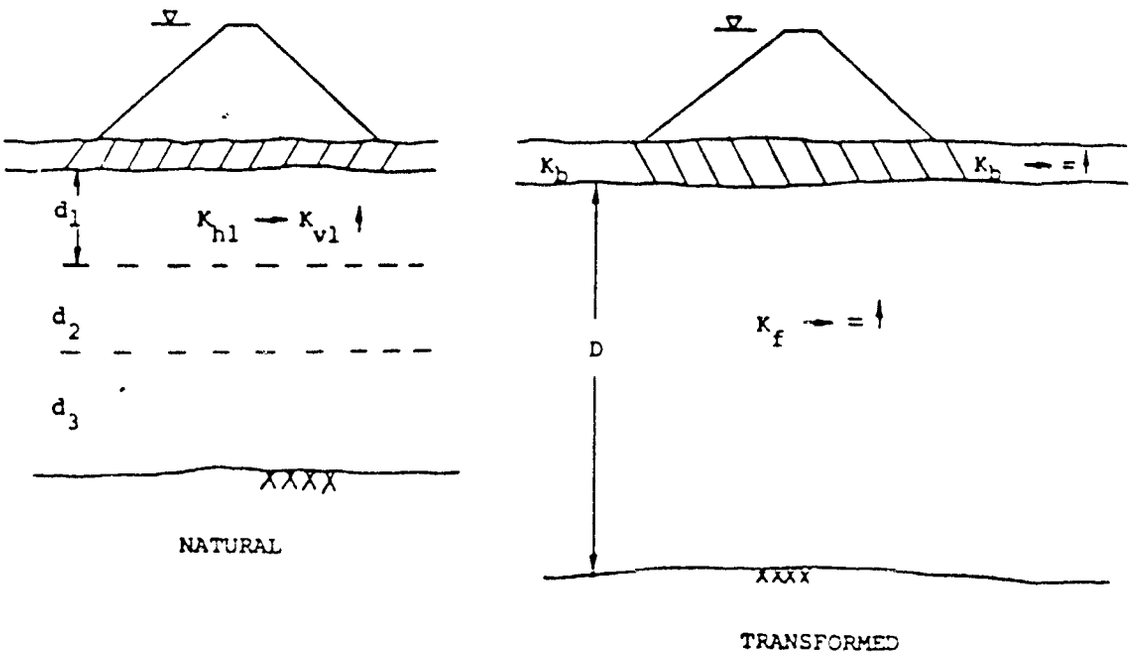


PLATE C-86

Walnut Creek - Raccoon River - Jordan Creek
West Des Moines - Des Moines, Iowa
Seepage Quantities - Underseepage
May 1990

Seepage Quanitities are in accordance with EM 1110-2-1913 Design and Construction of levees from 31 Mar 78.

General Levee Alignment Condition

Case 7 - Semipervious top strata both riverside and landside.

Seepage per unit length of levee,

$$Q_s = \$K_f H \qquad \text{Eq. B-11, Page B-12}$$

$$\$ = \frac{d}{X_1 + L_2 + X_3} \qquad \text{Eq. B-25, Page B-17}$$

or

$$\$ = \frac{D}{((L_1 + L_3) + L_2) + L_e} = \frac{D}{L_s + L_e} \qquad \text{RID Nomenclature}$$

Kf = Average (transformed) horizontal permeability

H = Head from design levee grade

Station Lineal Feet	D Feet	Ls+Le Feet	Kf Ft./Min	H Feet	L Feet	Q x 7.48 GPM/Lin.Ft.	Entry Source
0-800	35	501	0.22	6	1	0.69	JC
800-940	35	575	0.22	5	1	0.50	JC
990-2900	35	841	0.22	7.5	1	0.51	MM
2900-3400	10	451	0.22	8	1	0.29	MM
3400-3920	5	367	0.22	7	1	0.16	MM
3950-5100	2	240	0.22	7	1	0.10	MM
5100-5800	10	329	0.22	8.5	1	0.43	MM
5800-6800	30	600	0.32	7	1	0.84	MM
6800-7200	45	755	0.32	9	1	1.28	MM
7200-7800	45	500	0.32	11	1	2.37	MM
7800-8150	45	574	0.32	10.5	1	1.97	MM
8150-8550	45	562	0.32	19.5	1	3.[illegible]	MM
8550-8950	45	462	0.32	7	1	1.6[illegible]	MM
9000-9300	35	553	0.32	6	1	0.91	MM
9300-10050	35	737	0.28	3	1	0.30	RR
10050-10275	25	703	0.28	8	1	0.60	RR
10440-10700	25	529	0.28	7.5	1	0.74	RR
10700-11621	25	441	0.28	12	1	1.42	RR
11621-12100	25	358	0.28	14	1	2.05	RR
12100-12400	20	645	0.28	8	1	0.52	RR
12400-13600	20	732	0.28	12	1	0.69	WC
13600-14300	20	372	0.28	10	1	1.13	WC
14300-14750	20	352	0.28	9	1	1.07	WC
14750-15600	20	382	0.28	8	1	0.88	WC
15600-16200	25	395	0.28	9	1	1.19	WC
16200-16700	35	425	0.13	10	1	0.80	WC
16700-17000	35	420	0.13	7.5	1	0.61	WC
17000-17300	35	394	0.13	4.5	1	0.39	WC
17300-17753	35	420	0.13	3.5	1	0.28	WC
17753-18430	30	339	0.18	4	1	0.48	WC
18495-18940	20	466	0.18	5.5	1	0.32	WC
18950-19271	10	379	0.18	5	1	0.18	WC
19271-19518	10	367	0.18	8.5	1	0.31	WC
19518-20400	25	488	0.15	11.5	1	0.66	WC
20400-21100	25	409	0.15	9.5	1	0.45	WC
21100-21825	25	508	0.15	10.5	1	0.58	WC
21825-21970	25	730	0.15	9.5	1	0.37	WC
22000-22400	25	816	0.15	4.5	1	0.15	WC

Total Q (22,000 lineal feet) = 17,685 gpm/22,000 lin. ft.
Average Q = 0.80 gpm/lin.ft. = 0.11 cfm = 0.0018 cfs
Average H = 8.4 feet
Average Q, gpm/ft. head/lineal ft. levee = 0.10

Notes: JC - Jordan Creek
MM - Martin Marietta borrow pits
RR - Raccoon River
WC - Walnut Creek

A

P

P

E

DETAILED COST ESTIMATE

N

D

I

X

D

RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA

LOCAL FLOOD PROTECTION

APPENDIX D

DETAILED ESTIMATE OF COST

1. General. This Appendix contains the detailed cost estimate prepared for the West Des Moines - Des Moines, Iowa, Local Flood Protection Project, including Federal and non-Federal construction, real estate, planning, engineering, and design, and construction management costs. The current working estimate (CWE) prepared for this Design Memoradum (DM) level study was developed after review of project plans, discussion with the design team members, and review of costs for similiar construction projects. The Micro-Computer Aided Cost Estimating System (M-CACES), incorporating local wage and equipment rates, was utilized to assemble and calculate project element cost. Costs, including appropriate contingencies, are presented in accordance with EC 1110-2-536, Civil Works Project Cost Estimating - Code of Accounts.

2. Price Level. Project element costs are based on July 1990 prices. These costs are considered fair and reasonable to a well-equipped and capable contractor and include overhead and profit. Calculation of the Fully Funded Estimate (FFE) was done in accordance with guidance from CECW-B, dated 3 Mar 90, for Factors for Updating Study/Project Cost Estimates for FY 1992 Budget Submission.

3. Contingency Discussion. After review of project documents and discussion with engineering and construction personnel involved in the project, cost contingencies were developed which reflect the uncertainty associated with each cost item. Per EC 1110-2-263, these contingencies are based on qualified cost engineering judgement of the available design data, type of work involved and uncertainties associated with the work and schedule. Costs were not added to contingency amounts to cover items which are identified project requirements. The following discussion of major project features indicates the basis for contingency selection and assumptions made. For other elements not addressed below, the assignment of contingencies was deemed appropriate to account for the uncertainty in design and quantity calculation and further discussion is not included.

a. Feature 01, Lands and Damages.

Quantity calculations and costs for this work were developed by the Real Estate Division. Field research during cost development indicated several recent sales in the area which established a sound base to set current prices. Lands are a mix of agricultural and industrial fringe lands. Project lands are currently subject to flooding. The land is almost all in the floodplain and the project

follows the floodway along Walnut Creek. A 20 percent contingency was selected to account for uncertainty in this feature.

b. Feature 02, Relocations.

The quantities for this work were developed by Design Branch.

02.3.2.Q Utility line relocations are given a 20 percent contingency based on the assumptions that the gas line, water line and sanitary sewer are relocated in trenches excavated in common earth exclusive of rock.

02.3.2.R Power line relocations are given a 20 percent contingency based on recent discussions with power company representatives regarding cost for similar type work. Cost of work involving the fiber optic line crossings through the levee inspection trench required the assumption that the lines will be lowered and protected with split PVC incased in concrete. An estimate by US Sprint for a similiar relocation in Tama, Iowa, as part of a local flood project there, was followed. Site accessibility is not a problem.

02.1.2.B Road relocation construction items are given a 20 percent contingency to allow for increased haul distance for material disposal and possible dump charges for stripped asphalt. The contingency also accounts for the uncertainty in material prices, such as asphalt.

c. Feature 09, Channels and Canals.

Quantities were developed by Design Branch. Work requires cleanout of silted areas under and adjacent to bridges. The work is easily accessible and material to be removed is assumed to be wet material. Disposal is assumed within a 20 mile round trip and it assumed there are no dump charges. A 20 percent contingency is considered satisfactory for this work.

d. Feature 11, Levees and Floodwalls.

11.0.1.- Levees. Quantities were developed by Design Branch. Earth material for the levee construction will be excavated and hauled by truck from four known borrow areas. Three different size hauling crews were developed for hauling the material depending on length of haul. Some of the inspection trench material will be wasted at a cost that includes quoted dump charges. A 20 percent contingency is satisfactory for the levee work assuming no major borrow area relocation. Pipe removals are considered routine construction items with a 15 percent contingency. Riprap and bedding costs are given a 15 percent contingency because rock sources are locally available and have been used for other recent COE projects. Seeding prices for the borrow areas are given a 30 percent contingency pending final design and coverage requirements.

11.0.2.- Floodwall (I-Wall). Design and quantities were developed by Design Branch. A contingency of 20 percent is considered

satisfactory for most items, with a 25 percent contingency assigned to structural concrete because of the many different wall heights encountered in the project and included in this cost item. The uncertainty of applying an overall productivity to account for construction of each of the wall segments results in the use of this contingency amount. Site access is not a problem.

11.0.2.- Floodwall (Closure Structures). Quantities were developed by Design Branch. An average contingency factor of 20 percent is considered satisfactory for this work to account for needed coordination with railroads on the railroad closures and with possible city requirements for traffic control during construction of closures across city streets. The structures are not complex and detailed costs are included in the M-CACES estimate for items such as structural steel and painting. The structure's foundations are assumed founded in common earth with sheetpile perimeter walls. Production rate for driving sheetpile is estimated at 900 sf/day.

11.0.G.- Drainage. Quantities were developed by Design Branch and Cost Engineering Branch. Gatewell construction is given a 20 percent contingency to account for variation in foundation materials at the structure locations. From borings taken it is assumed that common earth will be excavated for the gatewell construction. Quoted prices were used for estimating the gate and drainage pipe costs. Quoted pipe prices also were used to estimate the cost of the interceptor sewers. A contingency of 20 percent is included to account for uncertainties in excavation during construction of the interceptors and manholes, including the need for dewatering. A 25 percent contingency is used for drainage ditch excavation to account for haul distance requirements and type of material excavated. Common earth excavation is assumed. A contingency of 30 percent is used for the excavation of wasted concrete in Ponding Area C to account for unknowns in quantity and compressive strength of the material. The unit cost to remove the material was estimated on the assumption that the material would have to be drilled and blasted. Haul distance is assumed at a 2 mile round trip with placement on the new levee slope as slope protection per discussion with Design Branch.

e. Feature 13. Pumping Plant.

13.0.1.- Gatewell Structures. Quantities were developed by Design Branch and Cost Engineering Branch personnel. Two gatewell type structures will be constructed and house pumps. These structures are given a 20 percent contingency to cover unknown site soil conditions and any needed dewatering cost. Quoted prices were used for estimating gate and pipe cost.

13.0.1.Q The pumps and discharge pipes are given a 20 percent contingency to allow for miscellaneous metals. The material cost for the pumps and discharge pipes is based on quoted prices.

13.0.1.R The electric control panels have a 20 percent contingency for electrical hookup to source pole and short conduit runs. Panel material price is based on a quote.

f. Feature 14, Recreation Facilities.

14.0.3.- Bicycle Path. Quantities were developed by Design Branch. A 20 percent contingency is satisfactory to cover uncertainties regarding site conditions and haul distance. Placement of the gravel base course assumes track mounted front end loaders working from stockpiles at 1000 feet intervals along the levee toe. A 30 percent contingency on traffic and warning lights is considered satisfactory to cover material price unknowns.

14.0.4.B Boat Ramp. A 20 percent contingency is considered satisfactory for this work to cover any additional requirements that may be added during subsequent design, such as riprap protection around the concrete ramp.

14.0.1.B Parking Lot. Construction items are given a 20 percent contingency to allow for change in haul distance which is assumed at 20 miles round trip for stripping and tree stump waste. Soft soil conditions may increase the quantity of gravel needed.

g. Feature 19, Buildings, Grounds and Utilities.

19.0.3.B Gatewells (Sanitary). Quantities were developed by Design Branch and Cost Engineering Branch personnel. Gatewell construction is given a 20 percent contingency to account for unknown soil types. Common earth was assumed. Quoted prices were used in estimating the gate and drainage pipe costs. The contingency is included to account for dewatering and maintainence of existing service during construction of the new sanitary sewer crossings.

19.0.3.Q Water and gas line relocations are given a 20 percent contingency to allow for soil excavation unknowns and material price differences.

19.0.3.B Revegetation cost is given a 10 percent contingency to allow for site access conditions and material prices.

The average contingency for the project's construction features is 21.5 percent.

h. Feature 30, Planning, Engineering & Design.

The engineering and design for this project includes all planning and design work necessary to complete the General Reevaluation Report, Design Memorandum, construction plans and specifications. This cost also includes engineering support during construction, preparation of as-built drawings and operation and maintenance manuals. The design effort for each of the stages of construction was analysed to determine the man-year effort required. This estimate is based upon monies expended to date, discussions between the project engineer and project manager, and historical data and experience gained on other projects of similiar nature.

i. Feature 31, Construction Mangement.

Construction management is studies and analyses of project reports, plans and specifications, and conferences of construction staff to become familiar with design requirements; biddability, contractiability, and operability reviews; preaward activities to acquaint prospective bidders with nature of work; administration of construction contracts; administration of A/E contracts which provide for supervision and inspection; establishment of bench marks and baselines required for layouts of construction, relocations, and clearing; review of shop drawings, manuals, catalog cuts, and other information submitted by the construction contractor; assure specifications compliance by supervision and inspection on construction work, conferences with the contractors to coordinate various features of the project and enforce compliance with schedules; sampling and testing during construction phase to determine suitability and compliance with plans and specifications; negotitiate with contractor on all contract modifications, including preparation of all contract documents required therefore; estimate quantities, determine periodic payments to contractors, and prepare, review, and approve contract payments; review and prove construction schedules and progress charts; prepare progress and completion reports; project management and administration not otherwise identified; and district overhead. These costs may be incurred at the job site, an area office, or at the District Office. For the construction of the West Des Moines - Des Moines Local Flood Protection Project, the estimated cost of construction management is $1,054,000 for a construction contract with a four year duration and an estimated value of $12.6 million.

4. Comparison With Previous Estimate.

Total project cost presented in this appendix differs from that shown in the latest PB-3, dated 1 Oct 89.

(Cost in 1000's Dollars)

Feature	Design Memo CWE July 1990	PB-3 1 Oct 89
01 Lands and Damages	2,012.0	3,550.0
02 Relocations	414.5	1,040.0
09 Channels & Canals	202.5	
11 Levees & Floodwalls	8,243.0	11,600.0
13 Pumping Plants	1,085.5	690.0
14 Recreation	328.0	460.0
19 Buildings, Grounds, & Utilities	737.5	
30 Planning, Engineering & Design	2,315.0	1,550.0
31 Construction Management	1,054.0	660.0
TOTAL PROJECT COST	$16,392.0	$19,550.0

The following summarizes the reasons for the cost changes.

a. Feature 01, Lands and Damages. The estimated value of lands and damages has decreased from $3,550,000 to $2,012,000. This decrease is attributable to moving the floodwall, originally located along the west side of 63rd Street, to the east side of this street. By making this alignment change, the cost of commercial property acquisition and business relocation is reduced. In addition, more accurate plan and profile drawings of the levee alignment reduced the taking lines and a detailed field investigation enabled more accurate estimation of the gross appraisal. This appraisal is reasonable based on the location of the levee.

b. Feature 02, Relocations. Change in cost of this feature resulted from elimination of some sanitary sewer line, increased cost of the fiber optic line work, and decreased contingencies, when compared to the GRR estimate, associated with all relocations in general. It also involved the transfer of $386,000 to feature 19.

c. Feature 09, Channels and Canals. This feature includes work, not included in the GRR, to excavate and clean out around the two bridges on the project. This work is required to incorporate the floodwall location change along 63rd Street. The estimated cost of this work item is $202,500.

d. Feature 11, Levees and Floodwalls. The GRR included wasting levee inspection trench materials offsite for a large part of the project in West Des Moines. After evaluation of recent borings, reuse of inspection trench materials is now acceptable, resulting in a cost reduction of roughly $1,512,000. More accurate quantity takeoffs and more detailed hauling prices represent a reduction in borrow costs of $1,240,000. $440,000 was transferred to pumping plants and $165,000 is transferred to feature 19 account.

e. Feature 13, Pumping Plant. The project has two permanent pumping stations. Pump optimization work since the GRR was published has resulted in the doubling of pumping capacity requirements. The larger pumps, appurtenances and structures have increased costs by $395,500. The current cost is based on price quotes from suppliers and detailed quantity takeoffs of the pump stations.

f. Feature 14, Recreation Facilities. Elimination of the guardrail and other minor components of the work, proposed in the GRR, resulted in the reduction of costs for this item from $460,000 to $328,000.

g. Feature 19, Buildings, Grounds and Utilities. Feature 19 was developed to include utilities and revegetation. Utility costs are approximately the same as those presented in the GRR. The amount of $386,000 was transferred in from feature 02. Revegetation costs of the project area have increased, based on more accurate price information to accomplish the proposed work. Revegetation costs are $351,500.

h. Feature 30, Planning, Engineering and Design. Total feature costs have increased to accurately reflect the effort required to

prepare plans and specifications. The manpower requirements needed to design specific features of the project have been analyzed. A summary of this analysis is shown in this appendix. Indirect rates, direct rates, and overhead rates have also been incorporated. The estimate also reflects the project management costs necessary through the design phase.

i. Feature 31, Construction Management. The DM cost estimate for this work is based on 6.75%, plus contingencies, of the total project construction cost, as opposed to the use of 6% in the GRR. The DM cost also includes an amount for overall management of the entire project, an element of work which was not previously identified and included in the GRR. A summary of these costs is shown in this appendix.

U.S. ARMY ENGINEERING DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

PROJECT COST ESTIMATE
FOR

RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA
LOCAL FLOOD PROTECTION

Estimate Date: July 1990

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Michael R. Cummings

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REVIEWED BY:

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FLOOD CONTROL PROJECT
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA

FLOOD CONTROL
PROJECT COST SUMMARY
DIVISION OF COST
JULY 1990

ACCOUNT	FEATURE	CURRENT WORKING ESTIMATE (CWE)				FULLY FUNDED ESTIMATE (FFE)			
		COST SHARED	LERRD WEST DES MOINES	LERRD DES MOINES	TOTAL LERRD	COST SHARED	LERRD WEST DES MOINES	LERRD DES MOINES	TOTAL LERRD
01.	LANDS AND DAMAGES	45,000	1,268,000	674,000	1,942,000	45,000	1,268,000	674 000	1,942,000
02	RELOCATIONS		366,600	47,900	414,500		434,100	56 700	490,800
09	CHANNELS AND CANALS	202,500				239,800			
11	LEVEES AND FLOODWALLS	7,598,000	538,400	106,600	645,000	8,996,000	637,500	126,200	763 700
13.	PUMP PLANTS	1,085,500				1,285,200			
19.	BUILDINGS, GROUNDS AND UTILITIES	737,500				873,200			
30.	PLANNING, ENGINEERING & DESIGN	2,287,000				2,514,300			
31	CONSTRUCTION MANAGEMENT	1,033,000				1,202 400			
	SUBTOTAL	12,988,500	2,173,000	828,500	3,001,500	15,155,900	2,339,600	856,900	3,196,500
	NON-FEDERAL CASH CONTRIBUTION (MINIMUM 5%)	(996,000)	794,300	201,700	996 000	(1,391,600)	1,109,850	281,750	1,391,600
	TOTAL	$11,992,500	$2,967,300	$1,030,200	$3,997,500	$13,764,300	$3,449,450	$1,138 650	$4,588,100
	COMBINED TOTAL FLOOD CONTROL COST	$13,990,000				$18 352,400			
	COMBINED TOTAL RECREATION COST	402,000				475,000			
	COMBINED TOTAL PROJECT COST	$16,392,000				$18,827 400			

NOTES

1 FLOOD CONTROL COST IS COST SHARED 75% FEDERAL AND 25% NON-FEDERAL

2. LERRD = LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS, DREDGING

3 CONSTRUCTION SCHEDULED FOR FEB 93 - MAY 96 FULLY FUNDED ESTIMATE (FFE) IS BASED ON MIDPOINT OF CONSTRUCTION DATE OF FEB 95 RESULTING IN INFLATION FACTORS OF 1 164 FOR SALARIES AND 1.184 FOR ALL OTHER COSTS PER EC 11-2-156, DATED 31 MAR 89, AND CECW-B MEMO, 3 APR. 90, SUBJECT FACTORS FOR THE FY 1992 BUDGET SUBMISSION

FLOOD CONTROL PROJECT
RACCON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA

RECREATION
PROJECT COST SUMMARY
DIVISION OF COST
JULY 1990

ACCOUNT	FEATURE	CURRENT WORKING ESTIMATE (CWE)				FULLY FUNDED ESTIMATE (FFE)			
		COST SHARED	LERRD WEST DES MOINES	LERRD DES MOINES	TOTAL LERRD	COST SHARED	LERRD WEST DES MOINES	LERRD DES MOINES	TOTAL LERRD
01.	LANDS AND DAMAGES	1,000	17,000	7,000	24 000	1,000	17,000	7,000	24,000
14	RECREATION FACILITIES	328,000				392,600			
30	PLANNING, ENGINEERING & DESIGN	28,000				32,800			
31	CONSTRUCTION MANAGEMENT	21,000				24,600			
	SUBTOTAL	378,000	17,000	7,000	24,000	451,000	17,000	7,000	24,000
	NON-FEDERAL CASH CONTRIBUTION (MINIMUM 5%)	(177,000)	96,800	80,200	177,000	(213,500)	116,700	96,800	213,500
	TOTAL	$201,000	$113,800	$87,200	$201,000	$237,500	$133,700	$103,800	$237 500
	COMBINED TOTAL RECREATION COST	$402,000				$475,000			

NOTES

1 RECREATION COST IS COST SHARED 50% FEDERAL AND 50% NON-FEDERAL

2 LERRD = LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS, DREDGING

3 CONSTRUCTION SCHEDULED FOR MAY 94 - MAY 96 FULLY FUNDED ESTIMATE (FFE) IS BASED ON MIDPOINT OF CONSTRUCTION DATE OF MAY 95, RESULTING IN INFLATION FACTORS OF 1 173 FOR SALARIES AND 1 197 FOR ALL OTHER COSTS PER EC 11-2-156, DATED 31 MAR 89, AND CECW-B MEMO, 3 APR 90, SUBJECT FACTORS FOR THE FY 1992 BUDGET SUBMISSION.

FLOOD CONTROL PROJECT
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA.
PROJECT COST ESTIMATE
JULY 1990 COST LEVEL

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED		LERRD		CONTINGENCY	CON %	REASONS
					WDM	DM	WDM	DM			
01	LANDS AND DAMAGES										
01 B - -	POST AUTHORIZATION PLANNING	1	LS	2,700.00		2,700			270	10%	1,2
01 B - -	POST AUTHORIZATION PLANNING	1	LS	2,700 00	2,700				270	10%	1,2
01 C - -	LOCAL COOPERATION AGREEMENT	1	LS	10,400 00		10,400			1,040	10%	1,2
01 C - -	LOCAL COOPERATION AGREEMENT	1	LS	10,200 00	10,200				1,020	10%	1,2
01 D - -	ACQUISITION	1	LS	63,000 00				63,000	12,600	20%	1,2
01 D - -	ACQUISITION	1	LS	105,000.00			105,000		21,000	20%	1,2
01 F - -	APPRAISAL	1	LS	5,600 00		5,600			800	15%	1,2
01 F - -	APPRAISAL	1	LS	42,000 00				42,000	8,400	20%	1,2
01 F - -	APPRAISAL	1	LS	9,600.00	9,600				1,400	15%	1,2
01 F - -	APPRAISAL	1	LS	70,000 00			70,000		14,000	20%	1,2
01 M 3 -	LAND PAYMENTS	1	LS	425,000 00				425,000	100,000	24%	1,2
01 M 3 -	LAND PAYMENTS	1	LS	875,000 00			875,000		200,000	23%	1,2
01 M 1 -	RELOCATION ASSISTANCE	1	LS	25,000 00				25,000	5,000	20%	1,2
	SUBTOTAL, COST-SHARED, WDM				22,500				2,690		
	SUBTOTAL, COST-SHARED, DM					18,700			2,110		
	SUBTOTAL, LERRD, WDM						1,050,000		235,000		
	SUBTOTAL, LERRD, DM							555,000	126,000		
	SUBTOTAL, LANDS AND DAMAGES				1,646,200						
	CONTINGENCIES, AVERAGE OF 22 2%								365,800		
01	TOTAL, LANDS AND DAMAGES				2,012,000						

REASONS FOR CONTINGENCIES.
1 QUANTITY UNKNOWNS
2 COST UNCERTAINTIES

FLOOD CONTROL PROJECT
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ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED WDM	COST-SHARED DM	LERRD WDM	LERRD DM	CONTINGENCY	CON %	REASONS
02.	RELOCATIONS										
02.1.-.-	ROADS										
02 1 - -	RELOCATE MARTIN-MARIETTA ROAD										
02 1 2 B	CLEARING & GRUBBING	0.40	ACR	3,530 00			1,412		282	20%	1,2
02 1 2 B	STRIPPING	167	CY	4 95			827		165	20%	1,2
02 1 2.B	EMBANKMENT	458	CY	3.35			1,536		307	20%	1,2
02 1 3.B	GRAVEL SURFACE	250	CY	32 30			8,075		1,615	20%	1,4
02 1 2 B	18" CMP DRAIN PIPE	40	LF	21.05			842		168	20%	1,4
02 1 - -	RELOCATE ROAD AT LUMBER YARD										
02.1 2 B	CLEARING & GRUBBING	0.50	ACR	3,530.00			1,765		353	20%	1,2
02.1 2 B	STRIPPING	667	CY	4.95			3,302		660	20%	1,2
02.1 2 B	EMBANKMENT	1,326	CY	3.35			4,442		888	20%	1,2
02 1.3 B	BASE COURSE	667	CY	40.65			27,114		5,423	20%	1,4
02 1 3 B	ASPHALTIC PAVEMENT	465	TON	50.00			23,250		4,650	20%	1,4
02.1.2.B	12" CMP DRAIN PIPE	90	LF	15 80			1,422		285	20%	1,4
	SUBTOTAL, ROADS						73,987		14,796		
02.3 -.-	CEMETERIES,UTILITIES, AND STRUCTURES										
02.3.3.E	REL FENCE,STA 193+50-215+50	2,200	LF	8.80			19,360		2,904	15%	2
02 3 2.R	POWER POLES & LINE	4	EA	4,077.00			16,308		3,261	20%	2,4
02.3.2.R	POWER POLES & LINE	5	EA	4,077.00				20,385	4,077	20%	2,4

REASONS FOR CONTINGENCIES
1 UNKNOWN HAUL DISTANCE
2. UNKNOWN SITE CONDITIONS.
3 UNKNOWN FINAL DESIGN
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ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED WDM	COST-SHARED DM	LERRD WDM	LERRD DM	CONTINGENCY	CON %	REASONS
02.3.-.-	CEMETERIES,UTILITIES, AND STRUCTURES (CONT)										
02.3.2.R	USWEST FIBR OPT LINE STA 102+00	1	EA	9,769.00				9,769	1,954	20%	2
02.3.2 R	SPRINT FIBR OPT LINE STA 102+00	1	EA	9,769.00				9,769	1,954	20%	2
02.3.2 R	SPRINT FIBR OPT LINE STA 9+90	1	EA	9,769.00			9,769		1,954	20%	2
02.3.2.R	USWEST FIBR OPT LINE STA 182+50	1	EA	9,769.00			9,769		1,954	20%	2
02 3.2.Q	FIRE HYDRANTS	5	EA	2,592 00			12,960		2,592	20%	2,4
02.3.2.Q	WATER LINE,6",STA.202+50 - 215+50	1,300	LF	18.10			23,530		4,706	20%	2,4
02 3.2.Q	GAS LINE, 3", STA. 41+72 - 43+63	280	LF	19.35			5,418		1,084	20%	2,4
02 3 2 Q	SAN S, 36"RCP, STA 202+50 - 215+50	1,300	LF	104.00			135,200		27,040	20%	2
	SUBTOTAL, CEM., UTILITIES AND STRUCTURES						232,314	39,923	45,495 7,985		
	SUBTOTAL, RELOCATIONS						346,224				
	CONTINGENCIES, AVERAGE OF 19 7%								68,276		
02	TOTAL, RELOCATIONS						414,500				

REASONS FOR CONTINGENCIES
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ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED WDM	COST-SHARED DM	LERRD WDM	LERRD DM	CONTINGENCY	CON %	REASONS
09.	CHANNELS AND CANALS										
09.0 2.-	WALNUT CREEK CLEANOUT @ GRAND AVE BR										
09 0 2.B	EXCAVATION & WASTE	9,200	CY	13 65	125,580				18,838	15%	1,2
	SUBTOTAL, GRAND AVE. BR				125,580				18,838		
09.0 2.-	WALNUT CREEK CLEANOUT @ 63RD ST BR										
09 0 2 B	EXCAVATION & WASTE	3 700	CY	13 65	50,505				7,577	15%	1,2
	SUBTOTAL, 63RD ST BR				50,505				7,577		
	SUBTOTAL, CHANNELS AND CANALS				176,085						
	CONTINGENCIES, AVERAGE OF 15 0%								26,415		
09.	TOTAL, CHANNELS AND CANALS				202,500						

REASONS FOR CONTINGENCIES
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ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED		LERRD		CONTINGENCY	CON %	REASONS
					WDM	DM	WDM	DM			
11.	LEVEES AND FLOODWALLS										
11.0.1.-	LEVEES										
11.0.1.B	EMBK FROM PND. AREA A.	49,000	CY	3.75	183,750				36,750	20.0%	1,2
11.0.1 B	EMBK FROM PND. AREA D	49,600	CY	3 75		186,000			37,200	20.0%	1,2
11.0.1.B	EMBK FROM EXIST LEVEE	9,000	CY	1.50		13,500			2,700	20 0%	2
11.0.1.B	EMBK FROM BORROW, WDM	96,989	CY	5 15	499,493				99,899	20.0%	1,2
11.0 1.B	EMBK FROM BORROW, DM	66,675	CY	6 60		440,055			88,011	20 0%	1,2
11.0.1 B	STRIPPING - 6", WDM	15,750	CY	2 60	40,950				8,190	20.0%	1,2
11.0 1 B	STRIPPING - 6", DM	11,050	CY	2 60		28,730			5,746	20.0%	1,2
11.0 1.B	INSP. TNCH., REM. & REPL	32,400	CY	2.65	85,860				17,172	20.0%	2
11.0.1.B	INSP TNCH, REM. & REPL.	23,700	CY	2 65		62,805			12,561	20.0%	2
11 0 1 B	INSP. TNCH. REM. & WASTE, REPL	8,900	CY	15 50	137,950				27,590	20.0%	1,2
11 0 1.B	CLR & GRUB AVE. DENSITY	2	ACR	4,078 00	8,156				1,631	20.0%	1,2
11 0 1 B	CLR & GRUB, MED. DENSITY	11	ACR	5,385 00	59,235				11,847	20.0%	1,2
11 0.1.B	CLR & GRUB, MED DENSITY	10	ACR	5,385 00		53,850			10,770	20.0%	1,2
11.0.1.B	REM. ROAD, STA 39+00 - 41+00	600	CY	3.45	2,070				414	20 0%	1,2
11.0.1.B	REM ROAD, STA 201+00 - 215+00	1,600	CY	3 45	5,520				1,104	20 0%	1,2
11 0 1.B	DEGRADE EXIST. LEVEE	18,150	CY	2.70		49,005			9,801	20.0%	1,2
11.0 1 B	SEEDING	26.6	ACR	2,347 00	62,431				6,243	10.0%	4

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ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED WDM	COST-SHARED DM	LERRD WDM	LERRD DM	CONTINGENCY	CON %	REASONS
11.0.1.-	LEVEES (CON'T)										
11.0.1.B	SEEDING	18 3	ACR	2,347 00		42,951			4,295	10%	4
11.0 1 B	RIPRAP,18"	750	TON	19.25		14,438			2,166	15%	1,4
11.0.1.B	BEDDING,6"	333	TON	16.25		3,608			541	15%	1,4
11 0.1.B	REMOVE 18"CMP, STA 127+80	82	LF	18 00		1,476			221	15%	2
11.0 1.B	REMOVE 18"CMP, STA 135+30	60	LF	20 15		1,209			181	15%	2
11.0 1.B	REMOVE 24" CMP, STA 153+00	50	LF	23 25		1,162			174	15%	2
11.0.1.B	REMOVE 24" CMP, STA 170+67	70	LF	20.50	1,435				215	15%	2
11.0.1.B	REMOVE 30" RCP,STA 170+85	70	LF	29.30		2,050			308	15%	2
11.0.1.B	REMOVE 30" RCP,STA 179+05	10	LF	48.25	483				72	15%	2
11.0.1.B	REMOVE 24" RCP,STA 183+65	10	LF	54.90	549				82	15%	2
11.0.1.B	REMOVE 36" RCP,STA 184+90	10	LF	60.25	603				90	15%	2
11.0.1.B	REMOVE 15" RCP, STA 186+00	60	LF	21.95	1,257				189	15%	2
11.0.1.B	REMOVE 36" RCP,STA 186+60	10	LF	60.25	603				90	15%	2
11.0.1.B	REMOVE 36" RCP,STA 191+45	10	LF	60 25	603				90	15%	2
11.0.1.B	REMOVE 30" CMP, STA 204+70	40	LF	27.85	1,114				167	15%	2
11.0.1.B	REMOVE 30" CMP, STA 214+45	38	LF	28.40	1,079				162	15%	2
11.0.1.B	REMOVE 30" CMP, STA 215+15	50	LF	25.35	1,268				190	15%	2
11.0.1.-	BOR/POND AREA A										
11.0.1.B	CLEAR AND GRUB	27	ACR	3,530.00	95,310				19,062	20%	2

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ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED WDM	COST-SHARED DM	LERRD WDM	LERRD DM	CONTINGENCY	CON %	REASONS
11.0.1.-	LEVEES (CON'T)										
11.0.1.b	STRIPPING 6", REPLACE	17,700	CY	3.55	62,835				12,567	20%	2
11.0.1.B	SEEDING	27	ACR	1,170.00	31,590				9,477	30%	2,3
11.0 1.-	BOR/POND AREA B										
11.0.1.B	CLEAR AND GRUB	1 5	ACR	3,530 00	5,295				1,059	20%	2
11.0.1.B	STRIPPING 6", REPLACE	2,420	CY	2 90	7,018				1,404	20%	2
11.0.1.B	SEEDING	3 1	ACR	1,170 00	3,627				1,088	30%	2,3
11.0.1.-	BOR/POND AREA D										
11.0.1.B	CLEAR AND GRUB	3.00	ACR	3,530.00		10,590			2,118	20%	2
11.0.1.B	STRIPPING 6", REPLACE	6,796	CY	2 90		19,709			3,942	20%	2
11 0.1.B	SEEDING	10 7	ACR	1,170.00		12,519			3,756	30%	2,3
	SUBTOTAL LEVEES				1,300,084				256,844		
						943,657			184,491		
11 0.2.-	FLOODWALL - I-WALL										
11 0.2.B	STRUCTURAL EXCAVATION	3,244	CY	1.70	5,515				1,103	20%	1,2
11 0.2.B	STRUCTURAL BACKFILL	2,719	CY	3.30	8,973				1,795	20%	1,4
11.0.2.C	REINFORCED CONCRETE	1,227	CY	288.00	353,376				88,344	25%	3,4
11.0.2.B	SHEETPILING	38,380	SF	16.25	623,675				124,735	20%	2,4
11.0.G B	GRAVEL FILTER	525	CY	28 65	15,042				3,008	20%	1,2
11 0.G B	CMP, 8"	1,854	LF	11 55	21,414				4,283	20%	3,4
	SUBTOTAL, FLOODWALL-I-WALL				1,027,995				223,268		

REASONS FOR CONTINGENCIES
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11 0.2.-	FLOODWALL- CLOSURE STRUCTURES										
11.0 2 -	FLDWALL -(RR)SB CLOS 9+50	1	EA	6,458.00	6,458				1,937	30%	3,4,5
11 0.2.-	FLDWALL -(RR)CLOS STA 39+00	1	EA	89,980 00	89,980				17,996	20%	2,4,5
11.0 2.-	FLDWALL -(RR)CLOS STA 101+45	1	EA	93,838 00		93,838			18,768	20%	2,4,5
11.0 2.-	FLDWALL - CLOS STA 184+30	1	EA	136,334.00	136,334				27,267	20%	2,4
11.0.2.-	FLDWALL -(RR)CLOS STA 189+00	1	EA	68,715 00	68,715				13,743	20%	2,4,5
11 0.2.-	FLDWALL - CLOS STA 192+60	1	EA	120,212 00	60,106	60,106			24,042	20%	2,4
11 0 2 -	FLDWALL - CLOS STA 214+75	1	EA	94,424 00	94,424				18,885	20%	2,4
11 0.2.-	FLDWALL -(RR)CLOS STA 216+40	1	EA	107,860.00	107,860				21,572	20%	2,4,5
	SUBTOTAL, FLDWALL CLOSURES				563,877	153,944			113,421 30,789		
11.0.C.-	ROAD RAMPS										
11 0 C.-	ROAD RAMPS, STA 10+78	1	EA	7,095 00			7,095		1,419	20%	1,2
11.0.C.-	ROAD RAMPS, STA 17+00	1	EA	548.00			548		110	20%	1,2
11.0.C.-	ROAD RAMPS, STA. 38+50	1	EA	1,006.00			1,006		201	20%	1,2
11.0 C.-	ROAD RAMPS, STA. 40+50	1	EA	1,006.00			1,006		201	20%	1,2
11 0.C.-	ROAD RAMPS, STA. 44+75	1	EA	6,563.00			6,563		1,313	20%	1,2,4
11.0.C.-	ROAD RAMPS, STA. 68+00	1	EA	8,013 00	8,013				1,603	20%	1,2,4
11.0.C -	ROAD RAMPS, STA 104+50	1	EA	1,006.00				1,006	201	20%	1,2
11 0 C -	ROAD RAMPS, STA 127+10	1	EA	10,725.00				10,725	2,145	20%	1,2,4

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ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED WDM	COST-SHARED DM	LERRD WDM	LERRD DM	CONTINGENCY	CON %	REASONS
11 0.C.-	ROAD RAMPS, (CONT)										
11.0.C.-	ROAD RAMPS, STA. 218+00	1	EA	7,955.00	7,955				1,591	20%	1,2,4
	SUBTOTAL ROAD RAMPS				15,968				3,194		
							16,218		3,244		
								11,731	2,346		
11.0.G.-	DRAINAGE										
11 0 G.-	GATEWELL B,48"SS,STA 13+50	1	EA	37,654 00	37,654				7,531	20%	2,4
11.0.G -	GATEWELL C,T-72"SS,STA 43+60	1	EA	112,390.00	112,390				22,478	20%	2,4
11.0.G.-	GATEWELL D, 6X6SS, STA 59+75	1	EA	78,125 00	78,125				15,625	20%	2,4
11 0 G.-	GATEWELL E,48"SS,STA 67+50	1	EA	45,118.00	45,118				9,024	20%	2,4
11 0.G.-	GATEWELL G,24"SS,STA 100+45	1	EA	17,903.00		17,903			3,581	20%	2,4
11.0 G.-	GATEWELL H,36"SS,STA 103+50	1	EA	31,777.00		31,777			6,355	20%	2,4
11 0 G.-	GATEWELL M,48"SS,STA 147+00	1	EA	50,613.00		50,613			10,123	20%	2,4
11 0 G -	GATEWELL Q,24"SS,STA 202+70	1	EA	22,919 00	22,919				4,584	20%	2,4
11 0 G -	GATEWELL S,48"SS,PND AREA A	1	EA	50,996 00	50,996				10,199	20%	2,4
	SUBTOTAL, GATEWELLS				347,202				69,441		
						100,293			20,059		
11 0 G.B	INTERCEPTOR,60",STA 57+50	950	LF	197.00			187,150		37,430	20%	2
11 0 G B	INTERCEPTOR, 42", STA 147-162+20	1,531	LF	96.20			73,641	73,641	29,456	20%	2
11 0.G.B	48"PC MH STA. 149+80	1	EA	1,682.00			841	841	336	20%	2,4
11 0 G B	48" PC MH STA 152+40	1	EA	1,09/ 00			547	547	218	20%	2,4
11 0.G.B	48" PC MH STA 155+30	1	EA	1,012			506	506	202	20%	2,4
11 0 G B	48"PC MH STA 159+10	1	EA	1,102.00			551	551	[illegible]	20%	2,4

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ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED WDM	COST-SHARED DM	LERRD WDM	LERRD DM	CONTINGENCY	CON %	REASONS
11.0 G.-	DRAINAGE (CONT)										
11.0 G B	48" PC MH STA 169+00	1	EA	1,094.00			547	547	218	20%	2,4
11.0 G B	48" PC MH STA 162+00	1	EA	1,044 00			522	522	208	20%	2,4
11 0.G.B	INTERCEPTOR,36",STA 181+50	284	LF	120 20			34,137		6,827	20%	2
11 0.G.B	INTERCEPTOR, MH,STA 184+30	1	EA	1,176 00			1,176		235	20%	2,4
11.0.G.B	INTERCEPTOR, 48", STA 184+30	62	LF	200.00			12,400		2,480	20%	2
11 0 G.B	INTERCEPTOR, MH, STA 181+90	1	EA	1,175 00			1,175		235	20%	2,4
11.0.G B	INTERCEPTOR, 54", STA 184+90	294	LF	201.00			59,094		11,819	20%	2
11.0.G B	INTERCEPTOR, 15", STA 185+90	77	LF	59 05			4,547		909	20%	2
11 0 G B	INTERCEPTOR, MH, STA 186+70	1	EA	1,783.00			1,783		357	20%	2,4
11 0.G.B	INTERCEPTOR, JCT BOX, STA 187+83	1	EA	4,671 00			4,671		934	20%	2,4
11.0 G.B	INTERCEPTOR, 36", STA 187+83	198	LF	95.20			18,850		3,770	20%	2
11.0.G.B	INTERCEPTOR, 15", STA 187+83	100	LF	58.50			5,850		1,170	20%	2
11.0.G B	INTERCEPTOR, MH, STA 189+90	1	EA	1,783 00			1,783		357	20%	2,4
11 0 G B	INTERCEPTOR, 36", STA 189+90	238	LF	95.15			22,646		4,529	20%	2
	SUBTOTAL, INTERCEPTORS						432,417		86,481		
								77,155	15,429		
11.0.G -	DRAINAGE DITCH, STA 13+60										
11.0.G B	EXCAVATION	2,726	CY	3 65	9,950				2,488	25%	1,2
11.0.G B	SEEDING	0.75	ACR	1,899.00	1,425				285	20%	2,3,4
	SUBTOTAL, DRAINAGE DITCH				11,375				2,773		

REASONS FOR CONTINGENCIES
1 UNKNOWN HAUL DISTANCE.
2 UNKNOWN SITE CONDITIONS
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4 UNKNOWN MATERIAL PRICE
5 CORRDINATION REQUIREMENTS
6 QUANTITY UNKNOWNS

FLOOD CONTROL PROJECT
RACCON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA.
PROJECT COST ESTIMATE
JULY 1990 COST LEVEL

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED WDM	COST-SHARED DM	LERRD WDM	LERRD DM	CONTINGENCY	CON %	REASONS
11 0 G.-	DRAINAGE (CONT)										
11 0.1.-	BOR/POND AREA C										
11.0.1 B	CLEAR AND GRUB	9 00	ACR	3,530 00	31,770				6,354	20%	2
11.0 1 B	STRIPPING 6", REPLACE	51,900	CY	2 00	103,800				20,760	20%	2,1
11 0 1.B	EXCAVATION, DUMPED CONCRETE	47,000	CY	33 60	1,579,200				473,731	30%	2,1,6
11 0.1.B	SEEDING	9 00	ACR	1,170 00	10,530				3,159	30%	2,3
	SUBTOTAL, PONDING AREA C				1,725,300				504,004		
	SUBTOTAL, DRAINAGE				2,083,877	100,293	432,417	77,155	576,218 20,059 86,481 15,429		
	SUBTOTAL, LEVEES AND FLOODWALLS				6,727,216						
	CONTINGENCIES, AVERAGE OF 22 5%								1,515,784		
11	TOTAL, LEVEES AND FLOODWALLS				8,243,000						

REASONS FOR CONTINGENCIES
1 UNKNOWN HAUL DISTANCE
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FLOOD CONTROL PROJECT
RACCON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA.
PROJECT COST ESTIMATE
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ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED WDM	COST-SHARED DM	LERRD WDM	LERRD DM	CONTINGENCY	CON %	REASONS
13	PUMPING PLANT										
13.0.1.-	GATEWELL F, STA 81+50	1	EA	126,783.00	126,783				25,357	20%	2,4
13.0 1 Q	PUMPS (50,000 GPM, TOTAL)	3	EA	95,143 00	285,429				57,341	20.1%	3
13.0 1.Q	DISCHARGE PIPES	3	EA	30,138 00	90,414				18,083	20%	3
13.0 1.R	ELEC. CONTROL PANELS	1	LS	18,427.00	18,427				3,686	20%	3,4
	SUBTOTAL, PUMP PLANT, 81+50				521,053				104,467		
13.0 1.-	GATEWELL O, STA 187+80	1	EA	173,311 00	173,311				34,662	20%	2,4
13.0 1 Q	PUMPS (20,000 GPM, TOTAL)	2	EA	73,310.00	146,620				29,324	20%	3
13.0 1.Q	DISCHARGE PIPES	2	EA	23,539.00	47,078				9,416	20%	3
13.0 1 R	ELEC. CONTROL PANELS	1	LS	16,307.00	16,307				3,262	20%	3,4
	SUBTOTAL, PUMP PLANT, 187+80				383,316				76,664		
	SUBTOTAL, PUMP PLANTS				904,369						
	CONTINGENCIES, AVERAGE OF 20.0%								181,131		
13.	TOTAL, PUMP PLANTS				1,085,500						

REASONS FOR CONTINGENCIES
1 UNKNOWN HAUL DISTANCE.
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FLOOD CONTROL PROJECT
RACCON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA.
PROJECT COST ESTIMATE
JULY 1990 COST LEVEL

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	*COST-SHARED* WDM	*COST-SHARED* DM	*LERRD* WDM	*LERRD* DM	CONTINGENCY	CON %	REASONS
14.	RECREATION FACILITIES										
14.0.3.-	BICYCLE PATH										
14.0.3.B	CLEARING AND GRUBBING	0.20	ACR	5,385.00	1,077				216	20%	1,2
14.0.3.B	GRAVEL BASE COURSE	963	CY	34.10	32,838				6,568	20%	1,4
14.0.3.B	GRAVEL BASE COURSE	506	CY	34.10		17,255			3,451	20%	1,4
14.0.3.B	ASPHALT - 2"	1,007	TON	60.00	60,420				12,084	20%	2,4
14.0.3.B	ASPHALT - 2"	530	TON	60.00		31,800			6,360	20%	2,4
14.0.3.B	HIGHWAY TRAFFIC LIGHT	1	EA	10,500.00	5,250	5,250			3,150	30%	4
14.0.3.B	RR FLASHING SIG. LIGHT WITH BELL	2	EA	14,709.00	29,400				8,753	29.8%	4
14.0.3.B	BICYCLE RAMP, EMBANKMENT	1,006	CY	3.50	3,521				704	20%	1,2
14.0.3.B	BICYCLE RAMP, EMBANKMENT	235	CY	3.50		822			165	20%	1,2
14.0.3.B	BICYCLE RAMP, GRVL BSE CRSE	59	CY	34.10	2,012				402	20%	1,4
14.0.3.B	BICYCLE RAMP, GRVL BSE CRSE	21	CY	34.10		716			143	20%	1,4
14.0.3.B	BICYCLE RAMP, ASPHALT - 2"	60	TON	60.00	3,600				720	20%	2,4
14.0.3.B	BICYCLE RAMP, ASPHALT - 2"	23	TON	60.00		1,380			276	20%	2,4
	SUBTOTAL, BICYCLE PATH				138,118	57,223			31,022 11,970		
14.0.2.B	VISTA, PAVED WITH BENCHES	1	EA	5,290.00	5,290				1,058	20%	1,4
14.0.4.B	BOAT RAMP	1	EA	26,250.00		26,250			5,250	20%	2,3,4
14.0.1.B	PARKING LOT, CLEAR, & GRUB	1	ACR	5,385.00		5,385			1,077	20%	1,2
14.0.1.B	PARKING LOT, STRIPPING	790	CY	7.50		5,925			1,185	20%	1,2

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FLOOD CONTROL PROJECT
RACCON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA.
PROJECT COST ESTIMATE
JULY 1990 COST LEVEL

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED WDM	COST-SHARED DM	LERRD WDM	LERRD DM	CONTINGENCY	CON %	REASONS
14.	RECREATION FACILITIES (CONT)										
14.0.1.B	PARKING LOT, GRAVEL SURFACE	865	CY	34.10		29,497			5,900	20%	2
14.0 1.B	BUMPER BLOCKS	500	LF	4 75		2,375			475	20%	4
	SUBTOTAL, VISTA, BOAT RAMP, PKG LOT				5,290	69,432			1,058 13,887		
	SUBTOTAL, RECREATION FACILITIES				270,063						
	CONTINGENCIES, AVERAGE OF 21 5%								57,937		
14.	TOTAL, RECREATION FACILITIES				328,000						

REASONS FOR CONTINGENCIES
1 UNKNOWN HAUL DISTANCE.
2. UNKNOWN SITE CONDITIONS.
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4. UNKNOWN MATERIAL PRICE
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6. QUANTITY UNKNOWNS

FLOOD CONTROL PROJECT
RACCON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA
PROJECT COST ESTIMATE
JULY 1990 COST LEVEL

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	COST-SHARED		LERRD		CONTINGENCY	CON %	REASONS
					WDM	DM	WDM	DM			
19.	BUILDING, GROUNDS, AND UTILITIES										
19.0.3.-	UTILLITIES, LINES AND SERVICE (THROUGH LEVEE)										
19 0.3 B	GATEWELL A, 15" SAN, STA 9+43	1	EA	12,016.00	12,016				2,403	20%	2,4
19.0.3 B	GATEWELL I, 42" SAN, STA 104+20	1	EA	40,848.00		40,848			8,170	20%	2,4
19 0.3 B	GATEWELL J, 42" SAN, STA 116+20	1	EA	46,402 00		46,402			9,280	20%	2,4
19 0.3.B	GATEWELL K, 24" SAN, STA 142+60	1	EA	26,270 00		26,270			5,254	20%	2,4
19 0.3.B	GATEWELL L, 48" SAN, STA 142+80	1	EA	43,858.00		43,858			8,772	20%	2,4
19.0.3.B	GATEWELL N, 15" SAN, STA 184+00	1	EA	16,884.00	16,884				3,377	20%	2,4
19 0 3 B	GATEWELL P, 36" SAN, STA 191+50	1	EA	24,523 00	24,523				4,905	20%	2,4
19 0.3.B	GATEWELL R, 36" SAN, STA 215+80	1	EA	37,708 00	37,708				7,542	20%	2,4
19 0.3 Q	WATERLINE, 6", STA. 10+60	40	LF	29 60	1,184				237	20%	2,4
19.0.3 Q	WATERLINE VALVE 6"	1	EA	711.00	711				142	20%	2,4
19.0.3 Q	WATERLINE, 4",STA 35+32	50	LF	27.00	1,350				270	20%	2,4
19 0.3 Q	WATERLINE VALVE 4"	1	EA	433 00	433				87	20%	2,4
19 0.3.Q	WATERLINE, 24" H.P, STA. 90+70	40	LF	124 00		4,960			992	20%	2,4
19 0.3.Q	WATERLINE VALVE 24"	1	EA	21,008.00		21,008			4,202	20%	2,4
19.0.3 Q	WATERLINE, 24" H P, STA. 177+42	40	LF	124.00		4,960			992	20%	2,4
19.0.3.Q	WATERLINE VALVE 24"	1	EA	21,008.00		21,008			4,202	20%	2,4
19.0.3.Q	WATERLINE, 6", STA 187+10	30	LF	29 60	888				178	20%	2,4
19 0.3 Q	WATERLINE VALVE 6"	1	EA	711 00	711				142	20%	2,4

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FLOOD CONTROL PROJECT
RACCON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA.
PROJECT COST ESTIMATE
JULY 1990 COST LEVEL

ACCOUNT CODE	ITEM	QUANTIT'	UNIT	UNIT PRICE	COST-SHARED WDM	COST-SHARED DM	LERRD WDM	LERRD DM	CONTINGENCY	CON %	REASONS
19.0 3 -	UTILITIES, LINES AND SERVICE (CONT)										
19.0.3 Q	WATERLINE, 6", STA. 187+10	85	LF	29.70	2,525				505	20%	2,4
19.0.3 Q	WATERLINE VALVE 6"	1	EA	711.00	711				142	20%	2,4
19.0.3 Q	GAS LINE, 3",STA 38+45	80	LF	23.20	1,856				371	20%	2,4
19.0.3.Q	GAS LINE, 3", STA 41+72	280	LF	23.20	6,496				1,299	20%	2,4
19 0 3 Q	GAS LINE,8",STA 185+14,SUPP DG CONST	700	LF	6.00	4,200				840	20%	2,4
	SUBTOTAL, UTILITIES, LINES AND SERVICE				112,196	209,314			22,440 41,864		
19.0.3.B	REVEGETATION, TREE PLANTINGS	1	LS	319,661.00	271,711	47,950			27,230 4,795	10.0% 10%	4 4
	SUBTOTAL, BUILDINGS, GROUNDS AND UTILITIES				641,171				96,329		
	CONTINGENCIES AVERAGE OF 15.0%										
19.	TOTAL, BUILDINGS, GROUNDS AND UTILITIES				737,500						

REASONS FOR CONTINGENCIES
1 UNKNOWN HAUL DISTANCE.
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4. UNKNOWN MATERIAL PRICE
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6 QUANTITY UNKNOWNS

Flood Control Project
Raccoon River and Walnut Creek
West Des Moines - Des Moines, Iowa
Cost Summary, Feature 30

The following breakdown is a summary of the remaining P,E & D costs for the project.

Plans & Specifications - Stage I

0.5 Man-Yr	- Struc. Eng	@	$45,000 =	$22,500
0.5 Man-Yr	- Struc Tech	@	40,000 =	20,000
0.33 Man-Yr	- Civ. Tech	@	40,000 =	13,200
0.5 Man-Yr	- Proj. Eng	@	45,000 =	22,500
0.25 Man-Yr	- R.O.W. Tech	@	40,000 =	10,000
0.125 Man-Yr	- Spec Writer	@	40,000 =	5,000
0.03 Man-Yr	- Cost Estimate	@	40,000 =	3,320
				96,520
Base Rate				
Tech indirect, direct and overhead 106% (96,520)				103,280
				$199,800
		15% contingencies		29,200
				$229,000

Plans & Specifications - Stage II

1.0 Man-Yr	- Struc Eng	@	$45,000 =	$ 45,000
1.0 Man-Yr	- Struc. Tech	@	40,000 =	40,000
0.5 Man-Yr	- Civil Tech	@	40,000 =	20,000
0.5 Man-Yr	- Proj Eng	@	45,000 =	22,500
0.25 Man-Yr	- R.O.W. Tech	@	40,000 =	10,000
0.125 Man-Yr	- Spec Writer	@	40,000 =	5,000
0.083 Man-Yr	- Cost Estimate	@	40,000 =	3,320
				145,820
Base Rate				
Tech indirect, direct & overhead 106% (145,820)				154,580
				$300,400
		15% contingencies		44,600
		Stage II - Total		$345,000

Plans & Specifications - Stage III

0.8 Man-Yr	- 2 Struc Eng	@	$45,000 =	$ 72,000
0.8 Man-Yr	- 2 Struc Tech	@	40,000 =	64,000
0.50 Man-Yr	- Civil Tech	@	40,000 =	20,000
0.50 Man-Yr	- Proj Eng	@	45,000 =	22,500
0.25 Man-Yr	- R.O.W. Tech	@	40,000 =	10,000
0.125 Man-Yr	- Spec Writer	@	40,000 =	5,000
0.083 Man-Yr	- Cost Estimate	@	40,000 =	3,320
				$196,820
Base Rate				
Tech indirect, direct & overhead 106% (196,820)				208,630
				$405,450
		15% contingencies		60,550
				$466,000

Flood Control Project
Raccoon River and Walnut Creek
West Des Moines - Des Moines, Iowa
Cost Summary, Feature 30

Engineering During Construction
Shop Drwg Review, As-Builts, Field Visits, Modifications, Operation and Maintenance Manual

FY 93	0.5 Man-Yr	@ $42,000	=	$ 21,000
FY 94	0.5 Man-Yr	@ 42,000	=	21,000
FY 95	0.5 Man-Yr	@ 42,000	=	21,000
FY 96	0.5 Man-Yr	@ 42,000	=	21,000
Base Rate				$ 84,000
Tech indirect, direct & overhead 106% (84,000)				89,000
				$173,000 1/

Life Cycle Project Management

	0.5 Man-Yr	@ $50,000	=	$ 25,000
106% (25,000)				$26,500
				$ 51,500 per year

FY 91	$ 51,500
FY 92	51,500
	$103,000 1/

Summary

Stage I Pts	229,000
Stage II	345,000
Stage III	466,000
E&D During Const	173,000
Life Cycle	103,000
	1,316,000
FY 91 work	- 229,000
FY 92 - FY 96	1,087,000
PED Thru 91	1,200,000
Total PE & D	2,287,000

1/ Contingencies figured into the man-year effort required.

Flood Control Project
Raccoon River and Walnut Creek
West Des Moines - Des Moines, Iowa
Cost Summary Feature 31

Construction Management

Supervision and Administration

Total Construction Cost		$ 11,011,000
	x	6.75%
	$	743,000
15% contingencies		111,000
subtotal $		854,000

Life Cycle Project Management

FY 93 - FY 96

$50,000 per year x 4 Fiscal Years =		$ 200,000
Total		$1,054,000

APPENDIX E

DESIGN ANALYSIS

RACCOON RIVER AND WALNUT CREEK
DES MOINES AND WEST DES MOINES, IOWA

LOCAL FLOOD PROTECTION

DESIGN MEMORANDUM

APPENDIX E
DESIGN ANALYSIS

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RACCOON RIVER AND WALNUT CREEK
DES MOINES AND WEST DES MOINES, IOWA

LOCAL FLOOD PROTECTION

DESIGN MEMORANDUM

APPENDIX E

DESIGN ANALYSIS

I - GENERAL

1. General. This appendix describes the methods used in designing the structures required for the Des Moines and West Des Moines, Iowa, Local Flood Protection project. Supporting information is included, such as design criteria, basic data and assumptions, loads, and loading conditions, and typical design computations and stability analyses. In accordance with ER 1110-2-265, sufficient design computations have been performed to establish accurate cost information. Detailed design computations on individual structures will be performed during the preparation of plans and specifications.

II - DESIGN CRITERIA

2. References. Working stresses, loading conditions, design assumptions, and other criteria were based on the applicable parts of the following references:

a. EM 1110-1-2101, "Working Stresses for Structural Design," dated 1 November 1963 with changes 1 and 2.

b. EM 1110-2-2000, "Standard Practice for Concrete," dated 5 September 198[illegible].

c. EM 1110-2-2502, "Retaining and Flood Walls," dated 31 March 1989.

d. ETL 1110-2-256, "Sliding Stability for Concrete Structures," dated 24 June 1981.

e. EM 1110-2-2906, "Design of Pile Foundations," working draft.

f. EC 1110-2-267, "Strength Design for Reinforced Concrete Structures," dated 31 January 1990.

3. Reinforced Concrete Structures. Reinforced concrete structures will be designed by Ultimate Strength Design (USD) in accordance with EC 1110-2-267. Concrete structures will have a 28-day minimum compressive strength of 4,000 pounds per square inch (psi).

4. Concrete Reinforcement. Concrete reinforcement design was based on the use of deformed billet-steel bars conforming to the requirements of ASTM A615, Grade 60, with a minimum yield stress of 60,000 psi. Design will be based on a yield strength of 60,000 psi. Concrete cover and minimum reinforcement will comply with EC 1110-2-267. The spacing, splicing, and bending requirements of the bars will be in accordance with ACI-318 and the ACI Detailing Manual - 1980.

5. Steel Sheet Piling. Steel for sheet piling will conform to the requirements of ASTM A328.

6. Structural Steel. Structural steel will conform to the requirements of ASTM A-36. Working stresses for the design of structural steel will be in accordance with EM 1110-1-2101. Minimum thickness of stress carrying members will be 5/16 inch. Skin plates shall have a minimum thickness of 3/8 inch.

III - DESIGN OF STRUCTURES

7. Gatewells. The rectangular cast-in-place gatewells will be designed using one foot wide section at the bottom of the gatewell. The computer program CFRAME (X0030) "Analysis of Plane Frame Structures" will be used to analyze stresses in the structure. EC 1110-2-267 will be used to design the reinforcing steel.

8. Walls.

I-Walls designed with computer. The I-walls will be designed as a cantilever wall using computer program CWALSHT (X0031), "Design/Analysis of Sheetpile Walls by Classical Methods." This program will design a cantilever sheet pile wall which depends solely on its embedment for stability. The net water pressure is assumed to vary linearly and reach equilibrium at the theoretical end of the piling. Coulomb earth pressure theory is used to evaluate the active and passive pressure coefficients. The program performs iterative solutions in which wall penetration is varied until conditions of equilibrium and other assumptions are satisfied. The output from the program includes the moment and shear ordinates at each 1-foot increment of depth. The equations of equilibrium used are those defined in "Substructure Analysis and Design" by Anderson. This program has been verified and has been reviewed by OCE.

9. Closure Structures.

a. Gates. The steel gates will be designed as simply supported structures spanning horizontally to vertical supports. Hydrostatic pressure will be computed with water at the top of the gate on the flood side and no water on the gate on the protected side. Allowable stresses will be in accordance with Column B (Hydraulic) (Basic Stress = 0.50 Fy) of Paragraph 11 EM 1110-1-2101.

b. Stability Analysis of Gate Monolith. The concrete gate monoliths will be designed in accordance with EM 1110-2-2502 (Reference

2d). Stability Criteria shown in Table 4-2 of the EM will be followed, with a minimum of two load cases being considered for each monolith:

Case I1 - Design Flood

Case I2 - Water to top of wall.

Other live load cases (truck or train on monolith) or dead load cases will be considered as applicable.

c. CNW RR Gate Closure Sta 103+57.

A detailed foundation analysis was performed for the gate closure structure across the Chicago and Northwestern Railroad tracks. This structure spans two tracks and was selected for analysis because of the large dead load that must be supported.

Analysis was performed for the following load cases:

Case I Floodside (Riverside) Water at El.44.2 (Top of Gate, Top of Freeboard), Protected Side (Landside) Water at El.39.2 (Ground Elevation) - Case is equivalent to Case I2 EM 1110-2-2502 Table 4-2 - Allowables increased 33-1/3% due to infrequency of loading.

Case II Floodside Water at El.41.2 (Design Flood), Protected Side Water at El.39.2 - Case is equivalent to Case I1 EM 1110-2-2502 Table 4-2.

Case III Gates Open, train load on flood side of gate monolith, both tracks. Lateral load = 0.15* (one track load) acting towards flood side. No water table.

Case IV Gates Open, train load on protected side of gate monolith, both tracks. Lateral load = 0.15* (one track load) acting towards protected side. No water table.

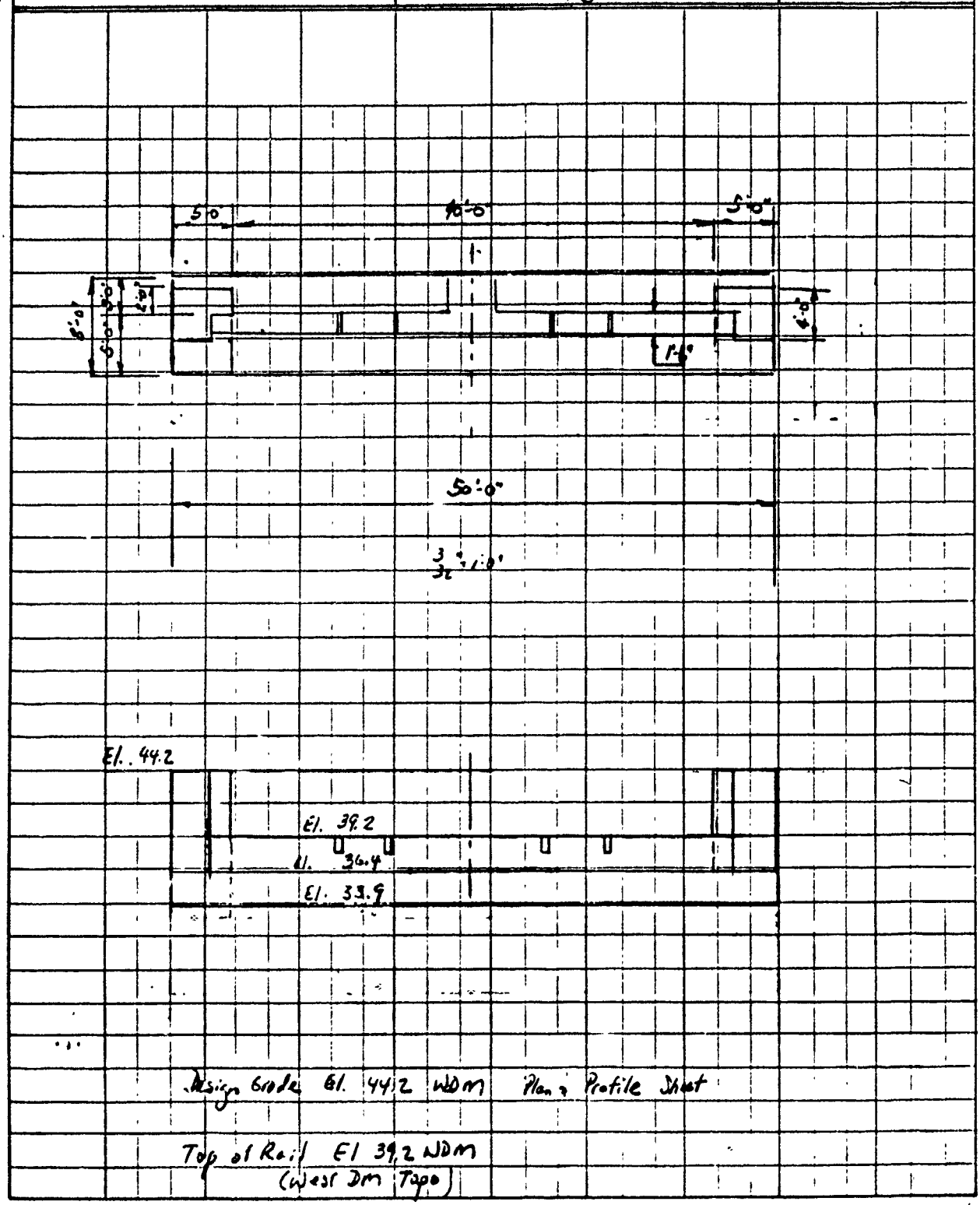
Case V Dead Load only.

Initial design was for a soil-supported foundation. Cohesive shear strength equal to 500 psf was derived from Boring WDM-89-70. This value was later revised upward to 800 psf (Q strength) and $\theta=24^{\circ}$ (S strength). After several design trials of the soil-supported foundation, it was concluded that a soil-supported foundation would not meet the bearing capacity criteria in EM 1110-2-2502, Tables 4-1 and 4-2. For cases III and IV the bearing capacity safety factor was computed to be 2.2 and criteria in EM 1110-2-2502 requires a safety factor of 3 for usual loading conditions. Two tracks loaded simultaneously require full live load according to AREA criteria and therefore the loading condition was considered "usual."

A pile-supported foundation was analyzed. Allowables were derived from a draft of new EM 1110-2-2906 "Design of Pile Foundations." Steel H piles were chosen because some piles are required to take tension loads under Case I. Pile analysis performed with computer program CPGA (X0080) showed pile loads below allowables for all load cases.

The remaining gated closure structures are shown as soil-supported. Preliminary design shows this will be adequate. Bearing capacity requirements are less severe since the CNW RR gate is the only closure with an active double track system. The Norfolk and Southern Railroad closure at station 220+00 has two tracks, but the spur track can be considered inactive for design purposes.

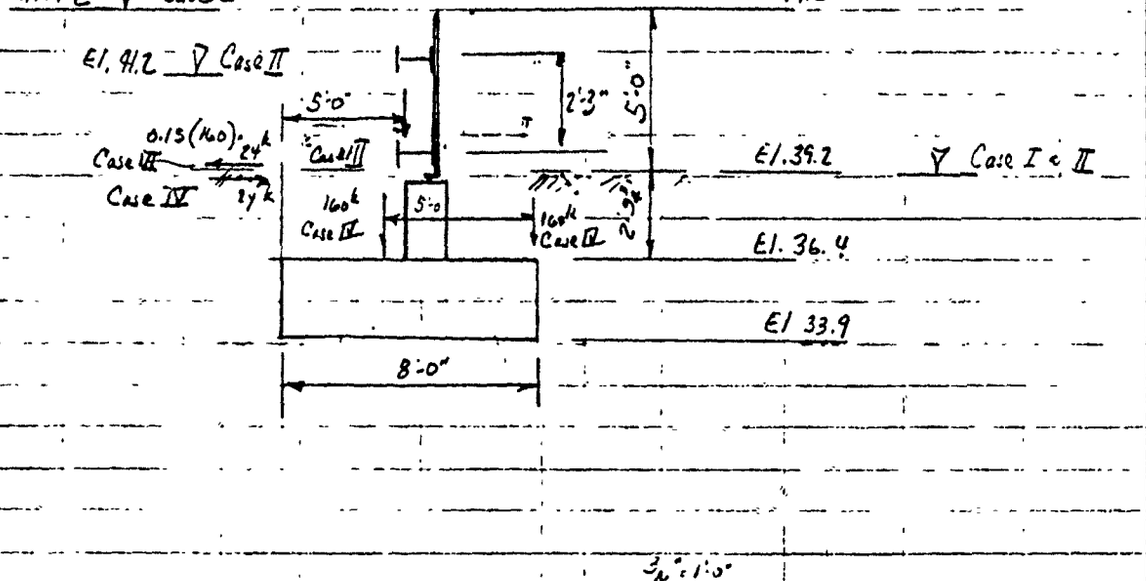
Subject		Date
WEST DES MOINES FLOOD CONTROL - CNW AR GATE		14 NOV 89
Computed by JGB	Checked by TJW	Sheet 1 of



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PLATE E-1

Subject	Date
NEAT DEC MONOS FLOOD CONTROL - CNW RR GATE	14 NOV 89
Computed by JSL / Checked by TJW	Sheet 2 of



Case I PS Water at El. 44.2 (Top of Freeboard)
PS Water at El. 39.2 (Top of Rail - Ground Elevation)

Case II PS water at El. 41.2 (Design Flood)
PS water at El. 39.2 (Top of Rail - Ground Elevation)

Case III Train Load on Flood Side, both tracks
Lateral Load @ 0.15x(one track load) acting towards PS no water table

Case IV Train Load on Protected Side, both tracks
Lateral Load = 0.15x(one track load) acting towards PS no water table

Case V Dead Load only, no water table

@ 0.15 Ref AREA 15.1.9.12.(a)

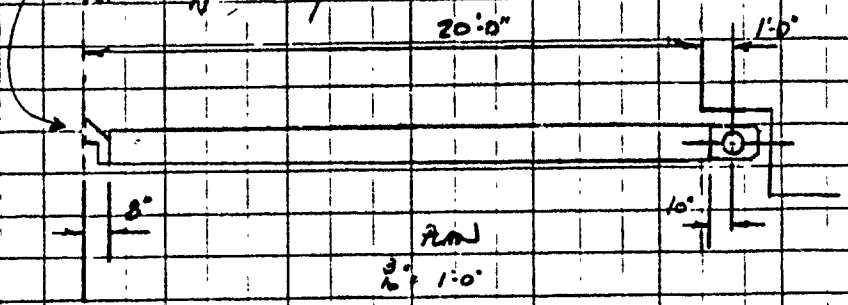
NCR Form 381b
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PLATE E-2

Subject WEST DES MOINES FLOOD CONTROL - CNN RR GATE		Date 1 FEB 90
Computed by JGB	Checked by TJW	Sheet 3 of

Gate Design

Center support provided



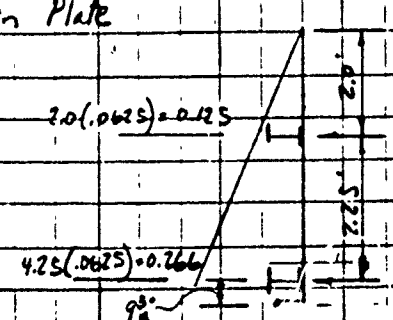
RAN
$\frac{3}{4}$" = 1'-0"

Design span length for Beams 21'-0 ℄ Rings to ℄ Center Support

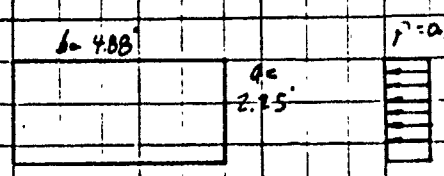
Skin plate length total = 21'-0 - (8" + 10") = 19'-6"

Each panel = 19'-6 ÷ 5 = 4'-10½"

Skin Plate



Panel



p = 0.200
approximately ⅔ diff
betw 0.125 and 0.266

Ref. Moments and Reactions for Rectangular Plates
Pg. 70.

$\frac{a}{b} = \frac{2.25}{4.88} = 0.46$ — use a/b = 0.50

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PLATE E-3

Subject		Date
WEST DES MOINES FLOOD CONTROL - CNW RL GATE		12 MAR 90
Computed by KB	Checked by TJW	Sheet 4 of

Gate Design

Skin Plate cont

Max Moment = $0.0813\, p\, q^2 = 0.0813(0.200)(2.25)^2$

$= 0.0825$ 'k/'

$M_b = 0.83(0.75)\, F_y = 0.83(0.75)(36) = 22.4$ ksi

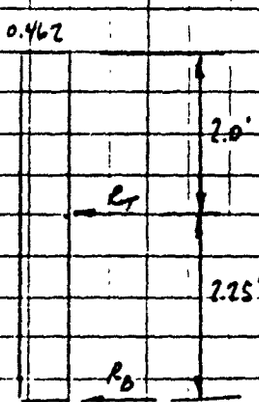
$S_{req'd} = \frac{M}{F_b} = \frac{(0.0825)(12)}{22.4} = 0.04\ in^3$

3/8" Skin plate $S = \frac{bt^2}{6} = \frac{12(0.375)^2}{6} = 0.28 > 0.04$ ok

Diaphragm plates — Mom, Reac for Rect. Plates pg. 40

$R_y = 0.514\,(p)(6) = 0.514(0.200)(2.25) = 0.231$ k/'

Load on Plates = 2 (0.231) = 0.462 (adjacent panels)



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PLATE E-4

Subject		Date
WEST DES MOINES FLOOD CONTROL - CNW RR GATE		12 MAR 90
Computed by	Checked by TJW	Sheet 5 of

Gate Design

Diaphragm plates cont

$\Sigma M_{RB} = 0.462(4.25)(2.13) - 2.25 R_T = 0$

$R_T = 1.86^k \leftarrow$

$\Sigma M_{RT} = 0.462(4.25)(0.12) - 2.25 R_B = 0$

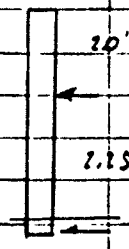
$R_B = 0.10^k \leftarrow$

Solve for max moment

at point of zero shear

$0.462 y = 1.86$

$y = 4.03'$ from top



$M = 0.462 \frac{4.03^2}{2} - 1.86(2.03) = 3.75 - 3.78 = -0.03^{\cdot k}$

$V = +2.0(0.462) - 1.86 = 0.92 - 1.86 = -0.94^k$

$M = 0.462 \frac{2.0^2}{2} = 0.924^{\cdot k}$

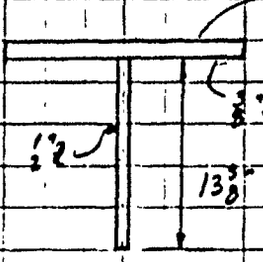
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PLATE E-5

Subject	Date
WEST DES MOINES FLOOD CONTROL - CNW ER GATE	12 MAR 90
Computed by JGB	**Checked by** TJW
	Sheet 6 of

Gate Design

Diaphragm plates cont — AISC Table B5.1 $b/t = 9.5/\sqrt{F_y} \approx 16/\sqrt{42}$



	A	y	Ay	Ay^2	I_o
1 @ 1/2 x 13 3/8	6.81	7.19	48.96	352.05	105.4
2 @ 3/8 x 12	4.50	0.19	0.86	0.16	—
	11.31		49.82	352.21	105.4

$$\bar{y} = \frac{\Sigma Ay}{\Sigma A} = \frac{49.82}{11.31} = 4.40$$

$$I = I_o + \Sigma Ay^2 - \Sigma Ay \cdot \bar{y} = 105.4 + 352.2 - 49.82 * 4.40$$

$$= 105.4 + 352.2 - 219.2 = 238.4 \text{ in}^4$$

$$S_{top} = \frac{238.4}{4.40} = 54.2 \text{ in}^3$$

$$S_{bot} = \frac{238.4}{14.12 - 4.40} = \frac{238.4}{9.72} = 24.5 \text{ in}^3$$

$$f_b = \frac{M}{S} = \frac{(0.924)(12)}{24.5} = 0.45 \text{ ksi} \quad \text{minimal}$$

$$f_v = \frac{V}{A_w} = \frac{0.94}{6.81} = 0.14 \text{ ksi} \quad \text{minimal}$$

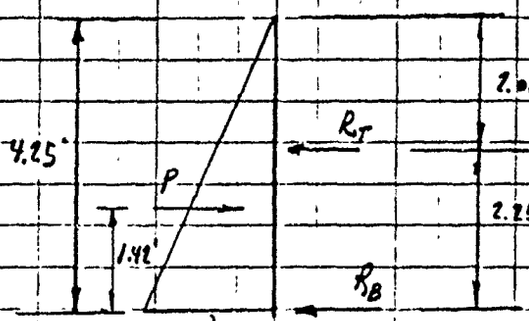
NCR Form 381b
1 Aug 80

PLATE E-6

Subject		Date
WEST DES MOINES FLOOD CONTROL - CNW RR GATE		2 FEB 90
Computed by JGB	Checked by TJW	Sheet 7 of

Gate Design

Horizontal Girders



$4.25(0.0625) = 0.266$

$P = \frac{1}{2}(0.266)(4.25) = 0.564^{k}/_{ft}$ →

$R_T = \frac{0.564(1.42)}{2.25} = 0.356^{k}/_{ft}$ ←

$R_B = \frac{0.564(0.83)}{2.25} = 0.208^{k}/_{ft}$ ←

Top Girder

$w = 0.356^{k}/_{ft}$

$M = \frac{1}{8}wl^2 = \frac{1}{8}(0.356)(21.0)^2 = 19.6^{ft\text{-}k}$

$V = \frac{1}{2}wl = \frac{1}{2}(0.356)(21.0) = 3.7^{k}$

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PLATE E-7

Subject	WEST DES MOINES FLOOD CONTROL - CNW RL GATE	Date	2 FEB 90
Computed by	JCB	Checked by	TJW
Sheet	8	of	

Gate Design

Horizontal Girders cont

$$S_{req'd} = \frac{M}{F_b} = \frac{19.6(12)}{20.0} = 11.8\ in^3$$

Try W 14x38 $S = 54.6$ min $t_f = \frac{5}{16}$"

Section is non-compact $F_y'' = 31.9\ ksi < 36\ ksi$

Lateral support of compression flange

$$F_b = \frac{10000\ C_b}{\ell d/A_f} = \frac{10000\ (1.0)}{(4.875)(12)(4.04)} = 42.3\ ksi$$

use 0.50 $F_y = 18\ ksi$

$$S_{req'd} = \frac{M}{F_b} = \frac{19.6(12)}{18} = 13.1\ in^2$$

$S_{provided} = 54.6\ in^3$

$$f_v = \frac{V}{A_w} = \frac{3.7}{(14.10)(0.310)} = 0.8\ ksi < F_v = 0.83(0.40)F_y$$

$= 0.83(0.40)(36)$

$= 12.0\ ksi$

ok

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PLATE E-8

Subject	WEST DES MOINES FLOOD CONTROL – CNW RR GATE	Date	5 FEB 80
Computed by JOB	Checked by TJW	Sheet 9	of

Estimated Weight of Gate

				WT (16) $\bar{x}$	
	$\frac{3}{8}$" Skin Plate	$\frac{3}{8}$ x 60 x 19'-4	15.3 (5)(15.33) =	1479	0.2
5.37'	2 - Beams	W 14 x 38 x 21'-3	2 (38) (21.25) =	1615	7.4
4'-0"	8 - Diagonals	½ x 2 x 5.37'	8 (3.4) (5.37) =	146	14.7
2:3	End Diaphragm				
22"	2 - ½ x 7½ x 1'-10"		2 (12.8) (1.83) =	47	7.4
29"	2 - ½ x 13 x 2'-5		2 (22.1) (2.42) =	107	7.4
6" 3" 10" 9" 2"	2 - ½ x 13 x 0'-6		2 (22.1) (0.50) =	22	7.4
		- ½ x 10 x 0'-7	- 2 (17.0) (.17) =	- 6	7.4
	Mid Diaphragm				
13 2:3	3 - ½ x 13	x 2'-3	3 (22.1) (2.29) =	149	7.4
				3559	16
					4.71

WT = 3571 (2) (1.15) = 8213 lb

2 gates

+2% for misc

= 9 k

C.G. = 16788.6 / 3559 = 4.71' from PS face

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PLATE E-9

Subject		Date
WEST DES MOINES FLOOD CONTROL - CNW RR GATE		21 JULY 90
Computed by JGB	Checked by	Sheet 10 of

Pile Constants

References: a) Tech. Report K-83-1 "Basic Pile Group Behavior"

b.) Tech Report ITL-89-3 "User's Guide CPGA Program"

Boring WDM-89-70 shows clays in top 10 feet*

cohesion = 480 to 540 psf (Appendix C)

Say c = 0.500 ksf

E_s = stiffness of horizontal subgrade reaction

$E_s = 32\, q_u$ (page D3-Ref a)

$= 32\,(2)(0.500) = 32$ ksf $\quad \frac{32}{144} = 0.222$ ksi

Use $E_s = 0.2$ ksi

(no reduction for cyclic loading or group action)

Use Steel Piles HP 12x53

E = 29 000 ksi Modulus of elasticity for steel

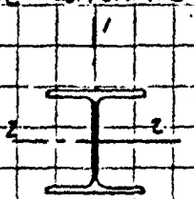
* Upper portion of the soil profile (10 pile diameters or less) usually controls the behavior of laterally loaded piles. - Reference EM 1110-2-2906 1 Jun 90 Paragraph 4e, page 4-33.

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PLATE E-10

Subject	WEST DES MOINES FLOOD CONTROL - CNW RR GATE	Date 21 JULY 90
Computed by JGB	Checked by	Sheet 11 of

Pile Constants



$I_1 = 127\ in^4$

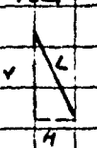
$S_1 = 21.1\ in^3$

$I_2 = 393\ in^4$

$S_2 = 66.8\ in^3$

$A = 15.5\ in^2$

$L = 50$ feet Boring WDM-89-70 shows refusal 45 feet down add 5 feet for better



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PLATE E-11

Subject		Date
WEST DES MOINES FLOOD CONTROL — CNW RR GATE		21 JULY 90
Computed by JEB	Checked by	Sheet 12 o.

Pile Constants

Allowable Loads

AC = allowable axial compression load

= allowable load at Pile Tip

allw compression pile tip — new EM pg 4-4

= 10.0 (15.5) = 155 k
Area

AT = allowable axial tension load

= adhesion × pile perimeter × length ÷ FS

adhesion = 0.5 C new EM pg 4-23

= 0.5 (0.500) = 0.250 ksf

$AT = \frac{0.250\,(4.0)(50)}{3.0} = 16.7$ say 15 k

ACC = allowable axial compressive force combined bending

new comp pg 4-5

= 18 (15.5) = 279 k

ATT = allowable axial tension force combined bending

= 18 (15.5) = 279 k

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PLATE E-12

Subject	Date
WEST DES MOINES FLOOD CONTROL - CNW RL GATE	21 JULY 90
Computed by JGB	Checked by
Sheet 13 of	

Pile Constants

Allowable Moments

AM1, AM2 = allowable moments for combined bending axis 1 and 2 respectively

AM1 = (18+S1 = 18(21.1) = 379.8

AM2 = (18+S2 = 18(66.8) = 1202.4

new EM pg 4-5 (non-compact section)

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PLATE E-13

Subject	Date
WEST DES MOINES FLOOD CONTROL - CNW RL GATE	21 JULY 90
Computed by LGB	**Checked by**
	Sheet 1F of

Concrete

El. 44.2

El. 39.2

9.50' 1.50 3.00'

① ②

El. 36.4

2.50'

El. 33.9

Concrete						F_V	Arm	Moment
Sill	①	(1.50)	(2.8)	(50-2(3.21))	(0.150)	= 27.5	4.25	116.9
Footing	②	(8.00)	(2.5)	(50.0)	(0.150)	= 150.0	4.00	600.0
Storage Bldg	③	(1.0)	(5.0)	(2.5)	(0.150)	= 1.9	8.5	16.2
Center Supp. Sill	④	(3.0)	(2.8)	(4.0)	(0.150)	= 5.0	6.5	32.5
Columns	⑤	2 (2.0)	(7.8)	(5.0)	(0.150)	= 23.4	6.0	140.4
	⑥	2 (2.0)	(7.8)	(1.79)	(0.150)	= 8.4	4.0	33.6
					S	216.2		939.6
Gate						8.2	4.6	37.7

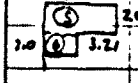


PLATE E-14

Subject	WEST DES MOINES FLOOD CONTROL - CNW RR GATE	Date	21 JULY 90
Computed by JGB	Checked by	Sheet 15	of

Earth

Vertical Wt

sat wt = 120 pcf
submerged wt = 57.5 pcf

			F_V	Arm	Moment
Cases I & II					
Flood Side	$(3.5)(2.3)(50 - 2(3.21))(0.0575)$	=	24.6	1.75	43.1
columns	$(3.0)(2.2)\ 2(3.21)\ (0.0575)$	=	3.1	1.50	4.7
Protected side	$(3.0)(2.3)(36)\ (0.0575)$	=	17.4	6.50	113.1
	$(10)(2.2)(5.0)\ (0.0575)$	=	0.8	7.50	6.0
			45.9		166.9

Case III, IV, V

use sat wt

$(F_V \& M) \times \frac{0.120}{0.0575} =$ 95.8 348.3

Horizontal

No horizontal pressures - tension crack develops

$c = 0.5$

$h = \frac{2c}{\delta} = \frac{2(0.5)}{0.0575} = 17.4$ ft

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PLATE E-15

Subject		Date
WEST DES MOINES Flood control - CMW RR GATES		21 JULY 90
Computed by JGB	Checked by	Sheet No of

Water

Vertical Wt

				Arm	Moment
Case I Flood Side					
①	(3.5)(1.8)(90 - 2(3.21))(0.0625) =	26.7	1.75	46.7	
②	(5.0)(5.0) " "	68.1	2.5	170.3	
columns ③	(3.0)(7.8) 2(3.21) (")	9.4	1.5	14.1	
		104.2		231.1	
Case II Flood Side					
①	Same as Case I	26.7		46.7	
②	(5.0)(2.0)(90-2(3.21))(0.0625) =	27.2	2.5	68.0	
columns ③	(3.0)(4.8)(2)(3.21) (") =	5.8	1.5	8.7	
		59.7		123.4	
Cases I & II Protected Side					
	(3.0)(2.8)(36)(0.0625) =	18.9	6.5	122.9	
2.8	(1.0)(2.8)(5.0)(0.0625) =	0.9	7.5	6.8	
		19.8		129.7	

Case I			
	Flood Side	104.2	231.1
	Protected Side	19.8	129.7
		124.0	360.8
Case II			
	Flood Side	59.7	123.4
	Protected Side	19.8	129.7
		79.5	253.1

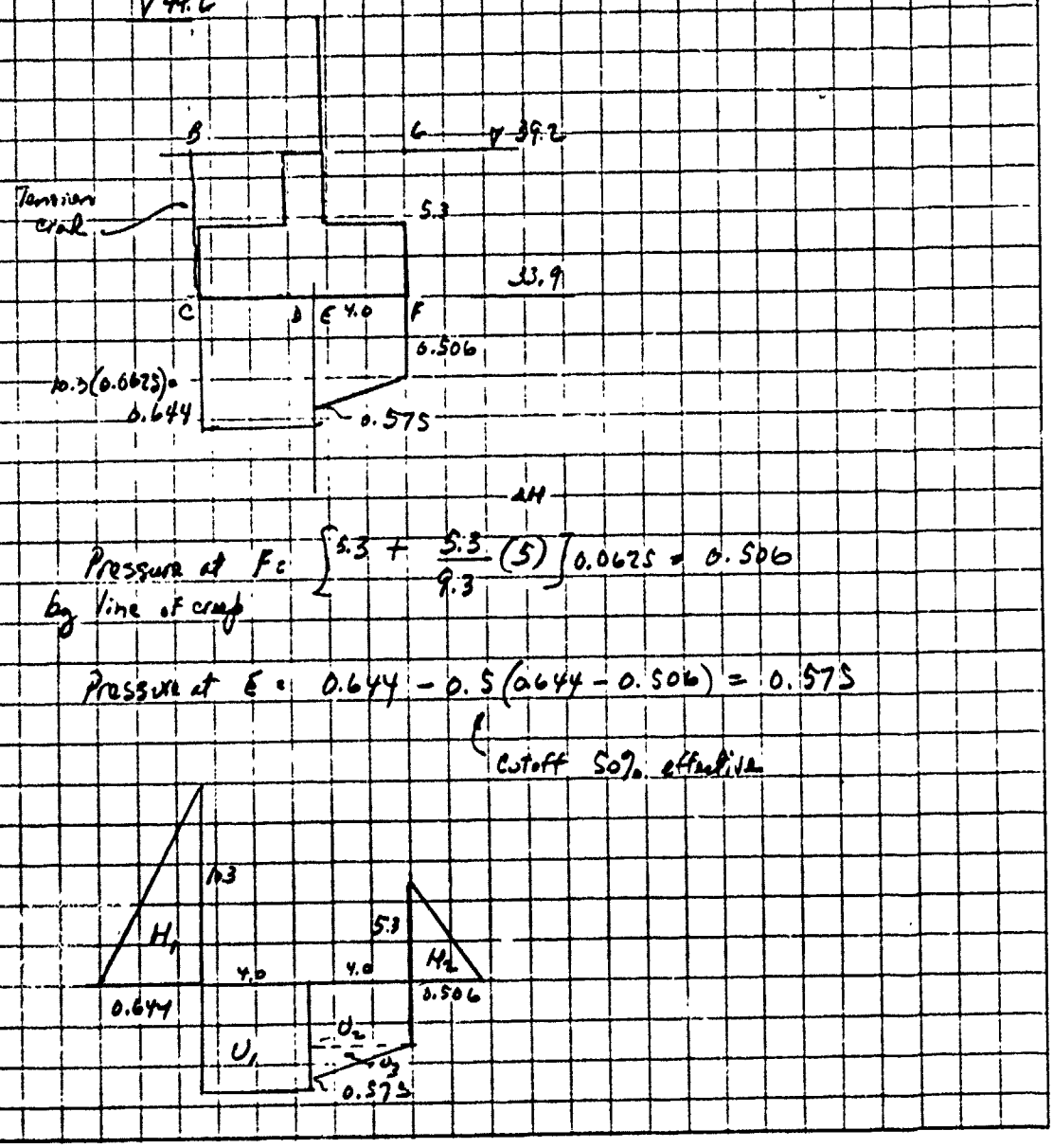
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PLATE E-16

Subject	Date
WEST DES MOINES FLOOD CONTROL – CNW RR GATE	21 JULY 90
Computed by KGB	**Checked by**
	Sheet 17 of

Water

Case I



Pressure at F_c by line of creep $\left\{5.3 + \frac{5.3}{9.3}(5)\right\}0.0625 = 0.506$

Pressure at E: $0.644 - 0.5(0.644 - 0.506) = 0.575$

(Cutoff 50% effective)

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PLATE E-17

Subject	WEST DES MOINES FLOOD CONTROL - CNW RR GATE	Date	21 JULY 93
Computed by	JGB	Checked by	Sheet 18 of

Water

Case I

Horizontal

		$F_H \rightarrow$		$M \circlearrowright$
H_1	$\frac{1}{2}(0.644)(10.3)(50.0) =$	165.8	3.43	568.7
H_2	$-\frac{1}{2}(6.506)(3.3)(50.0) =$	− 67.0	1.77	− 118.6
		98.8		450.1

Uplift

		$F_V \downarrow$		$M \circlearrowright$
U_1	$0.644(4.0)(50.0) =$	− 128.8	2.0	− 257.6
U_2	$0.506(4.0)(50.0) =$	− 101.2	6.0	− 607.2
U_3	$\frac{1}{2}(0.069)(4.0)(50)$	− 6.9	5.33	− 36.8
		− 236.9		− 901.6

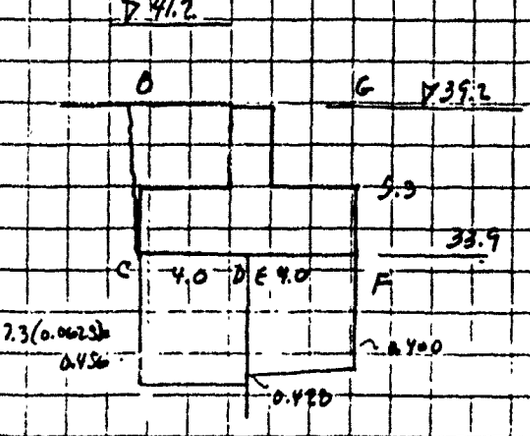
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PLATE E-18

Subject	Date
WEST DES MOINES FLOOD CONTROL - CANAL LL GATE	21 JULY 90
Computed by JGB / Checked by	Sheet 19 of

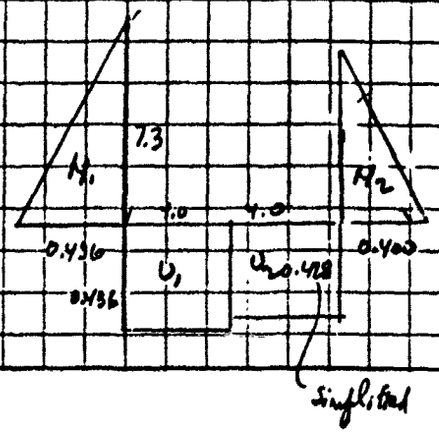
Water

Case II



Pressure at $F = \left[5.3 + \frac{5.3}{9.3}(2)\right] 0.0625 = 0.400$

Pressure at $E = 0.456 - 0.50\,(0.456 - 0.400) = 0.428$



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PLATE E-19

Subject	Date
WEST 783 MONROE FLOOD CONTROL - CNW - RL GATE	21 JULY 90
Computed by JGB / Checked by	Sheet 20 of

Water

Case II

Horizontal

	F_H →		M ↻
H_1 = ½ (0.456) (7.3) (50) =	83.2	2.43	202.1
H_2 = −½ (0.400) (5.3) (50) =	−53.0	1.77	−93.8
	30.2		108.4

Uplift

	F_V ↓+		M ↻
U_1 0.456 (4.0) (50)	−91.2	2.0	−182.4
U_2 0.428 (4.0) (50)	−85.6	6.0	−513.6
	−176.8		−696.0

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PLATE E-20

Subject	WEST DES MOINES FLOOD CONTROL - CNW RR GATE	Date 21 JULY 90
Computed by JGB	Checked by	Sheet 21 of

Train Loads

Case III

	F_H	F_V	Arm	Moment
Cooper E-60 1 axle BOL 2 trains ROK		160.0	0	0
		160.0	5.0	800.0
		320.0	381-33.9	800.0
	-24.0		5.3	- 127.2
	-24.0	320.0		672.8

Case IV

	F_H	F_V		Moment
		160.0	3.0	480.0
		160.0	8.0	1280.0
		320.0		1760.0
	24.0		5.3	+ 127.2
	24.0	320.0		1887.2

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PLATE E-21

Subject	WEST DES MOINES FLOOD CONTROL - ENW AL GATE	Date	21 JULY 80
Computed by JGB	Checked by	Sheet 22	of

Summary

Case I	$F_V \downarrow +$	$F_H \rightarrow +$	Moment ⊙
Concrete	216.2		939.6
Gate	8.2		37.7
Vertical Earth	45.9		166.9
Water Vertical	124.0		360.8
Water Horiz		98.8	450.1
Uplift	-236.9		-901.6
Σ	157.4	98.8	1053.5

NCR Form 1 Aug 80 381b

PLATE E-22

Subject		Date
WEST DES MOINES FLOOD CONTROL - CWW RR GATE		21 JULY 90
Computed by JGB	Checked by	Sheet 23 of

Summary

Case II	F_V ↓	F_H →	Moment ↻
Concrete	216.2		939.6
Gate	8.2		37.7
Vertical Earth	45.9		166.9
Water Vertical	79.5		253.1
Water Horiz		30.2	108.4
Uplift	-176.8		-696.0
Σ	173.0	30.2	809.7

NCR Form 381b
1 Aug 80

PLATE E-23

Subject		Date
WEST DES MOINES FLOOD CONTROL – CNW. RR GATE		21 JULY 93
Computed by JGB	Checked by	Sheet 24 of

Summary

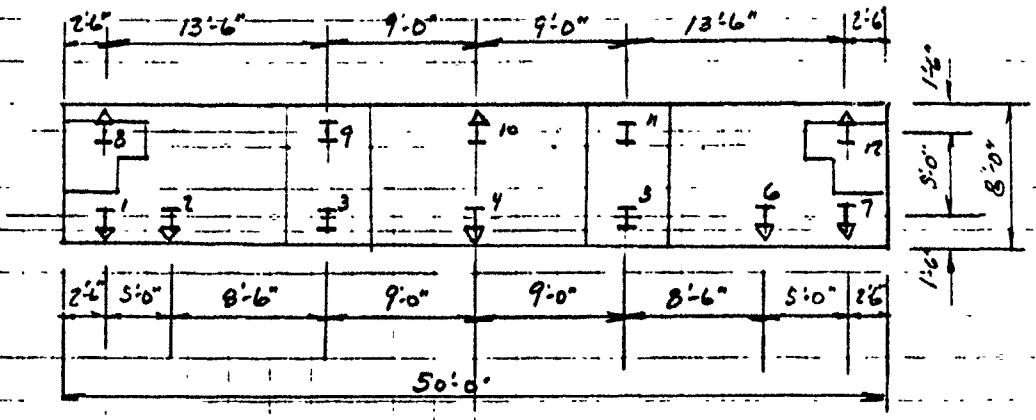
	F_V ↓+	F_H ⇒	Moment ↺+
Case III			
Concrete	216.2		939.6
Gate	8.2		37.7
Vertical Earth	95.8		348.3
Subtotal	(320.2)		(1325.6)
Train	320.0	-24.0	672.8
Σ	640.2	-24.0	1998.4
Case IV			
Concrete, Gate, Earth	320.2		1325.6
	320.0	+24.0	1887.2
Σ	640.2		3212.8
Case V			
Concrete, Gate Earth	320.2		1325.6

NCR Form
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PLATE E-24

Subject		Date
WEST DES MOINES FLOOD CONTROL - CANAL RR GATE		2 JULY 90
Computed by JGB	Checked by	Sheet 25 of

Pile Layout



Battered piles 2.5V on 1H

Maximum pile loads from CPGA Pile Analysis

Max Tension Load = 13.3^k Piles 1, 2, 4, 6, 7

Case I

Allowable = 15.0 (1.333) = 20.0^k

overstress factor for Case I -- unusual case

Max Compression Load = 107.3^k Piles 9 & 11

Case IV

Allowable = 150^k

All piles HP 12x53

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PLATE E-25

```
C:\CPGA>TYPE JB1102
10 WEST DES MOINES   CNWW RR GATE
20 PROP 29000 127 393 15.5 1.0 0 ALL
30 SOIL ES 0.2 LEN 50.0 0 ALL
40 PIN ALL
50 ALLOW H 155 15 279 279 379.8 1202.4 ALL
55 FOVSTR 1.333 1.333  1
60 BATTER 2.5  1 2 4 6 7 8 10 12
70 BATTER 0  3 5 9 11
80 ANGLE 90  1 TO 7
90 ANGLE 270  8 TO 12
100 PILE 1 -22.5 -1.5 0   8 -22.5 -6.5 0
110 ROW X 7 1   5.0 8.5 9.0  9.0 8.5 5.0
120 ROW X 5 8  13.5 9.0 9.0 13.5
130 LOAD 1  0 -98.8 157.4 -1053.5 0 0
140 LOAD 2  0 -30.2 173.0  -809.7 0 0
150 LOAD 3  0 +24.0 640.2 -1998.4 0 0
160 LOAD 4  0 -24.0 640.2 -3212.8 0 0
170 LOAD 5  0 0 320.2 -1325.6 0 0
180 TOUT 1 2 4 5
190 PFO ALL

C:\CPGA>X0080
**********************************
*  CORPS PROGRAM  #  X0080       *
*  MICRO VERSION  # 89/08/11     *
**********************************


CPGA - CASE PILE GROUP ANALYSIS PROGRAM
RUN DATE: 90/11/03  RUN TIME:  6.33.51


    FOR PILES WITH UNSUPPORTED HEIGHT:
         A. CPGA CANNOT CALCULATE PMAXMOM FOR NH TYPE SOIL
         B. THE ALLOWABLE STRESS CHECKS, ASC AND AST, ARE
            NOT FULLY DEVELOPED FOR UNSUPPORTED PILES.
            WORK IS IN PROGRESS TO COMPLETE THIS ASPECT OF CPGA.

    ELASTIC CENTER LOCATION IS NOT COMPUTED FOR 3-DIMENSIONAL PROBLEMS.


DO YOU WANT TO USE AN EXISTING FILE OR INTERACTIVE INPUT?
ENTER F OR I.
F
ENTER DATA FILE NAME.
JB1102
WEST DES MOINES   CNWW RR GATE
WILL OUTPUT BE PLOTTED BY CPGG? (Y OR N)
N
```

PLATE E-26)

THERE ARE 12 PILES AND

5 LOAD CASES IN THIS RUN.

ALL PILE COORDINATES ARE CONTAINED WITHIN A BOX

	X	Y	Z
WITH DIAGONAL COORDINATES = (	-22.50 ,	-6.50 ,	.00)
(	22.50 ,	-1.50 ,	.00)

****

PILE PROPERTIES AS INPUT

E	I1	I2	A	C33	B66
KSI	IN**4	IN**4	IN**2		
.29000E+05	.12700E+03	.39300E+03	.15500E+02	.10000E+01	.00000E+00

THESE PILE PROPERTIES APPLY TO THE FOLLOWING PILES -

ALL

****

SOIL DESCRIPTIONS AS INPUT

ES	ESOIL	LENGTH	L	LU
	K/IN**2		FT	FT
	.20000E+00	L	.50000E+02	.00000E+00

THIS SOIL DESCRIPTION APPLIES TO THE FOLLOWING PILES -

ALL

****

PILE GEOMETRY AS INPUT AND/OR GENERATED

NUM	X FT	Y FT	Z FT	BATTER	ANGLE	LENGTH FT	FIXITY
1	-22.50	-1.50	.00	2.50	90.00	50.00	P
2	-17.50	-1.50	.00	2.50	90.00	50.00	P
3	-9.00	-1.50	.00	V	90.00	50.00	P
4	.00	-1.50	.00	2.50	90.00	50.00	P
5	9.00	-1.50	.00	V	90.00	50.00	P
6	17.50	-1.50	.00	2.50	90.00	50.00	P
7	22.50	-1.50	.00	2.50	90.00	50.00	P
8	-22.50	-6.50	.00	2.50	270.00	50.00	P
9	-9.00	-6.50	.00	V	270.00	50.00	P
10	.00	-6.50	.00	2.50	270.00	50.00	P
11	9.00	-6.50	.00	V	270.00	50.00	P
12	22.50	-6.50	.00	2.50	270.00	50.00	P
						600.00	

****

APPLIED LOADS

PLATE E-27

LOAD CASE	PX K	PY K	PZ K	MX FT K	MY FT K	MZ FT K	OVERSTRESS COM	TEN

1	.0	-98.8	157.4	-1053.5	.0	.0	1.33	1.33
2	.0	-30.2	173.0	-809.7	.0	.0		
3	.0	24.0	640.2	-1998.4	.0	.0		
4	.0	-24.0	640.2	-3212.8	.0	.0		
5	.0	.0	320.2	-1325.6	.0	.0		

12 PILES 5 LOAD CASES

LOAD CASE 1. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 5.

LOAD CASE 2. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 0.

LOAD CASE 3. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 0.

LOAD CASE 4. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 0.

LOAD CASE 5. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 0.

****

PILE CAP DISPLACEMENTS

LOAD CASE	DX IN	DY IN	DZ IN	RX RAD	RY RAD	RZ RAD
1	-.7725E-07	-.1352E+00	.4021E-01	.2904E-03	-.4361E-12	-.5466E-11
2	-.3467E-07	-.5037E-01	.2860E-01	.9979E-04	-.2932E-12	-.3675E-11
3	-.3401E-07	-.1021E+00	.1430E+00	.1350E-02	-.7339E-12	-.9199E-11
4	-.8327E-07	.5526E-01	-.1015E-01	-.1966E-02	-.9213E-12	-.1155E-10
5	-.2974E-07	-.6858E-02	.2960E-01	-.2310E-03	-.4156E-12	-.5209E-11

****

PILE FORCES IN LOCAL GEOMETRY

M1 & M2 NOT AT PILE HEAD FOR PINNED PILES
* INDICATES PILE FAILURE
INDICATES CBF BASED ON MOMENTS DUE TO (F3*EMIN) FOR CONCRETE PILES
B INDICATES BUCKLING CONTROLS

LOAD CASE - 1

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF
1	-1.7	.0	-13.3	.0	67.3	.0	.66	.08
2	-1.7	.0	-13.3	.0	67.3	.0	.66	.08
3	-1.7	.0	26.2	.0	65.7	.0	.13	.11
4	-1.7	.0	-13.3	.0	67.3	.0	.66	.08
5	-1.7	.0	26.2	.0	65.7	.0	.13	.11
6	-1.7	.0	-13.3	.0	67.3	.0	.66	.08
7	-1.7	.0	-13.3	.0	67.3	.0	.66	.08
8	1.5	.0	49.8	.0	-57.9	.0	.24	.17
9	1.7	.0	13.2	.0	-65.7	.0	.06	.08
10	1.5	.0	49.8	.0	-57.9	.0	.24	.17
11	1.7	.0	13.2	.0	-65.7	.0	.06	.08
12	1.5	.0	49.8	.0	-57.9	.0	.24	.17

PLATE E-2[illegible]

LOAD CASE - 2

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF
1	-.7	.0	4.6	.0	27.6	.0	.03	.04
2	-.7	.0	4.6	.0	27.6	.0	.03	.04
3	-.6	.0	20.1	.0	24.5	.0	.13	.09
4	-.7	.0	4.6	.0	27.6	.0	.03	.04
5	-.6	.0	20.1	.0	24.5	.0	.13	.09
6	-.7	.0	4.6	.0	27.6	.0	.03	.04
7	-.7	.0	4.6	.0	27.6	.0	.03	.04
8	.5	.0	28.5	.0	-19.0	.0	.18	.12
9	.6	.0	15.6	.0	-24.5	.0	.10	.08
10	.5	.0	28.5	.0	-19.0	.0	.18	.12
11	.6	.0	15.6	.0	-24.5	.0	.10	.08
12	.5	.0	28.5	.0	-19.0	.0	.18	.12

LOAD CASE - 3

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF
1	-1.7	.0	54.2	.0	67.5	.0	.35	.25
2	-1.7	.0	54.2	.0	67.5	.0	.35	.25
3	-1.3	.0	89.0	.0	49.7	.0	.57	.36
4	-1.7	.0	54.2	.0	67.5	.0	.35	.25
5	-1.3	.0	89.0	.0	49.7	.0	.57	.36
6	-1.7	.0	54.2	.0	67.5	.0	.35	.25
7	-1.7	.0	54.2	.0	67.5	.0	.35	.25
8	1.0	.0	54.6	.0	-39.3	.0	.35	.23
9	1.3	.0	28.3	.0	-49.7	.0	.18	.14
10	1.0	.0	54.6	.0	-39.3	.0	.35	.23
11	1.3	.0	28.3	.0	-49.7	.0	.18	.14
12	1.0	.0	54.6	.0	-39.3	.0	.35	.23

LOAD CASE - 4

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF
1	.5	.0	32.9	.0	-20.4	.0	.21	.13
2	.5	.0	32.9	.0	-20.4	.0	.21	.13
3	.7	.0	18.9	.0	-26.9	.0	.12	.09
4	.5	.0	32.9	.0	-20.4	.0	.21	.13
5	.7	.0	18.9	.0	-26.9	.0	.12	.09
6	.5	.0	32.9	.0	-20.4	.0	.21	.13
7	.5	.0	32.9	.0	-20.4	.0	.21	.13
8	-1.3	.0	84.2	.0	50.8	.0	.54	.34
9	-.7	.0	107.3	.0	26.9	.0	.69	.41
10	-1.3	.0	84.2	.0	50.8	.0	.54	.34
11	-.7	.0	107.3	.0	26.9	.0	.69	.41
12	-1.3	.0	84.2	.0	50.8	.0	.54	.34

LOAD CASE - 5

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF
1	-.2	.0	21.6	.0	9.2	.0	.14	.08
2	-.2	.0	21.6	.0	9.2	.0	.14	.08

PLATE E-29

```
  4      -.2       .0     21.6        .0        9.2        .0   .14   .08
  5      -.1       .0     25.3        .0        3.3        .0   .16   .09
  6      -.2       .0     21.6        .0        9.2        .0   .14   .08
  7      -.2       .0     21.6        .0        9.2        .0   .14   .08
  8      -.1       .0     35.0        .0        5.5        .0   .23   .13
  9       .1       .0     35.7        .0       -3.3        .0   .23   .13
 10      -.1       .0     35.0        .0        5.5        .0   .23   .13
 11       .1       .0     35.7        .0       -3.3        .0   .23   .13
 12      -.1       .0     35.0        .0        5.5        .0   .23   .13
SHOULD THE INPUT FILE NAMED
JB1102
BE LISTED? (Y OR N)
N


ENTER CHANGE TO INPUT FILE OR * WHEN DONE.
*
RUN CPGA AGAIN? (Y OR N)
N


NO FILES WERE GENERATED DURING THIS RUN.
Stop - Program terminated.
```

PLATE E-30

PUMPING STATION DESIGN ANALYSIS

APPENDIX F

RACCOON RIVER AND WALNUT CREEK
DES MOINES AND WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION

DESIGN MEMORANDUM

APPENDIX F

PUMPING STATION DESIGN ANALYSIS

TABLE OF CONTENTS

Subject	Paragraph	Page
Purpose and Scope	1	F-1
General	2	F-1
Station Features	3	F-1
Control Sequence	4	F-2
Electrical	5	F-2
References	6	F-2

PLATES

Plates	Plate No.
Walnut Creek Pumping Station	F-1 - F-14
Raccoon River Pumping Station	F-15 - F-28

Raccoon River and Walnut Creek
West Des Moines and Des Moines, Iowa
Local Flood Protection

Appendix F

Pumping Stations

1. Purpose and Scope. The purpose of this appendix is to present the preliminary design of the pumping stations for the West Des Moines - Des Moines Local Flood Protection Project. Pump manufacturer's engineering information for standard catalog units were used to develop the design presented in this appendix. Pump sizing and layout are based on the efficient operation of the pump station and ease of normal maintenance.

2. General. Two pumping stations are required for this project. Both will contain submersible propeller type pumps. The pumping stations will be used to evacuate interior drainage during blocked gravity conditions.

One pumping station will be located on Walnut Creek just north of the Grand Avenue bridge. This station will handle on demand pumping of drainage area number 2 during blocked gravity. This station is designed to handle 20,000 gallons per minute.

The second station will be located south of downtown West Des Moines along the Raccoon River. This station will evacuate interior drainage from area number 5 and underseepage along the Raccoon River portion of the levee. This station is designed to handle 50,000 gallons per minute.

Both stations will utilize manual and automatic controls for maintaining proper water elevations. All electrical equipment necessary for the pumping station on Walnut Creek will be contained inside the pumping station structure as shown on plate 49. Electrical equipment for the Raccoon River station will be placed on top of the structure as shown on plate 47. All control and power panels will be weatherproofed, secured, and placed above the standard project flood level, except as shown on plate 49. Pump and motor removal will be accomplished by a mobile crane. A hand cleanable barscreen is to be provided in the sump intake well for protection of the pump impellers against debris.

3. Station Features. The first station will be supplied with water via a 5-foot by 7-foot reinforced concrete box culvert running underneath 63rd Street, Des Moines. A 5-foot by 7-foot rectangular electrically operated sluice gate will be provided to close the culvert during blocked gravity conditions. Two 32-inch, 13,300 gpm submersible pumps of axial or mixed flow type will be utilized for pumping the interior drainage.

The second station located on the Raccoon River will also be supplied by a reinforced box culvert 7-feet wide by 5-feet high. A 5'x7' electrically operated sluice gate will be provided to close the culvert during blocked gravity conditions. Three - 40 inch, 16,600 gpm submersible pumps of axial or mixed flow type will be utilized for pumping interior drainage and underseepage.

4. Control Sequence. During blocked gravity conditions indicating high river stages, the pumping stations will be activated to evacuate interior drainage and underseepage. The pumps will be either manually or automatically activated. Pump activation will be initiated by preset elevations on mercury float switches located in the forebay of the pumping station. Each pump will automatically turn off at a preset elevation.

5. Electrical. All submersible pumps at the station will be operated with electrical motors. Power will be provided by the Iowa Power Company of Des Moines, Iowa. They have a number of fossil and nuclear generating and plants are interconnected with other utilities in the area. They are considered a reliable source of power. Two high voltage power systems are available in the area, 13KV and 7.6 KV, 3 phase supply is sufficient to effectively operate the pumping stations. Power to the pumping stations will be tapped from the 7.6 KV source and transformed down with a 150 KVA transformer located on a concrete pad next to the pumping stations. Reduced voltage starting is not required. However, delayed starting will be provided to preclude the possibility of all pump motors starting simultaneously. Local ownership of the power service will be on the 480 volt side of the transformer. The Government, through its contractor, will pay for connection charges including the power line and transformer. Iowa Power will own and maintain the high voltage service including the transformer.

Both pumping stations will possess motor loads between 51KW to 75KW. The first station will need 75HP motors and the second will require 100HP motors. In addition, one motor of approximately 3HP for each sluice gate will be required. A power control panel will be located on the transformer pad and will house a separate 480/240/120 volt transformer for lighting, receptacles, and the control circuitry.

6. References. The following references were used as general guidance for the design of the pumping stations:

a. ETL 1110-2-313, "Hydraulic Design Guidance for Rectangular Sumps of Small Pumping Stations with Vertical Pumps and Ponded Approaches."

b. EM 1110-2-3101, "Pumping Stations - Local Cooperation and Ceneral Considerations."

c. EM 1110-2-3102, "General Principles of Pumping Station Design and Layout."

d. EM 1110-2-3104, "Structural and Architectural Design of Pumping Stations."

e. EM 1110-2-3105, "Mechanical and Electrical Design of Pumping Stations."

Subject	Pumping Stations - West Des Moines, Iowa	Date 26 June 90
Computed by Keith Haas	Checked by RVC	Sheet 1 of 14

Walnut Creek Pumping Station

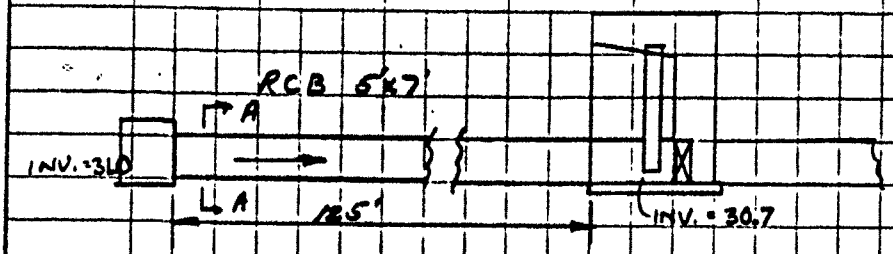
20,000 gpm 2 - Pumps

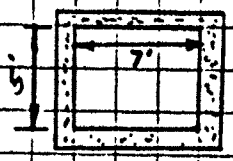
This pumping station pumps storm sewers from drainage area No. 2. A junction box is being constructed to intercept a 54" R.C.P. and two 36" R.C.P. A reinforced concrete box culvert will serve as the pumping station inlet. Details of the station are shown on PLATE 19. The location of the station is shown on PLATE 19.

Pumping stations for this project were designed using the FLYGT pump design manual and applicable Corps ETL's and EM's concerning submersible pumps. This pumping station will have a 10 percent probability in any given year of being used for a 10-hour period. The pumping station will have a 50 percent probability any given year of being used for brief periods of evacuation pumping in anticipation of potential Walnut Creek flooding.

An easement will be needed in the Val Lanes parking lot for infrequent ponding.

Subject	Walnut Creek Pumping Station	Date June 90
Computed by K. Haas	Checked by	Sheet 2 of 1





SECTION A-A

NOTE: NO TRASH RACK IS PLANNED SINCE THIS IS A STORM SEWER

DETERMINE SYSTEM HEAD LOSSES:

a. Junction Box Losses
b) 5'x7' RCB Losses
c) Pump pipe losses & Static Head Requirement
d) Exit losses

a) Junction Box Losses

Ref Handbook of Civil Engineers 3rd Edition
F.S. Merritt pp. 21-45

Use $K_e = 0.50$ for entrance loss

NCR Form
1 Aug 80 381b

PLATE F-2

Subject	Walnut Creek Pumping Station	Date June 90
Computed by K. Hass	Checked by RE	Sheet 3 of 14

Assume R.C.B. flowing full

20,000 gpm station
2 pumps
The station must be capable of pumping 2/3 of design capacity with one pump down.

$20{,}000 \times \frac{2}{3} = 13{,}333$ gpm $= 29.7$ c.f.s. $= Q$

(Assume both pumps running) $Q = 2 \times 29.7 = 59.4$ c.f.s.

$Q = V \times A \qquad V = Q/A$

$V = (59.4)\ ft^3/s / (5' \times 7')$

$V = 1.7$ ft/s

$V^2/2G = (1.7)^2/2(32.2\ ft/s^2) = 0.0448$ ft

H_L ent. $= K_e\ V^2/2G = 0.5\ (0.0448) = 0.0224$ ft

H_L ent. $= 0.0224$ ft

b) 5'-7" R.C.B. Losses

Pipe Length = 12.5 ft.

Assume pipe flowing full

Use Darcy-Weisbach equation (no bends)

$$h_L = f \frac{L V^2}{D 2g}$$

PLATE F-3

Subject	Walnut Creek Pumping Station	Date JUNE 90
Computed by K. Hess	Checked by RW	Sheet 4 of 14

where $f = 0.025$

$L = 125'$

$D = 4A/P = 4(35)/24 = 5.83$

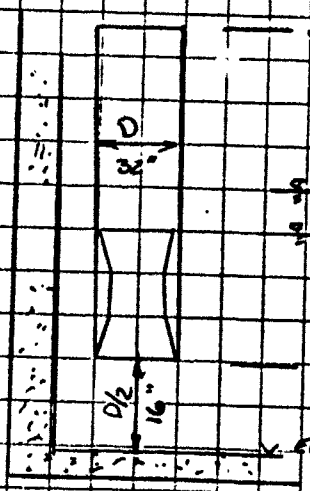
$V^2/2G = 0.0448$ ft from previous comps

$$h_L = \frac{(0.025)(125)(0.0448)}{5.83}$$

$h_L = 0.024$ ft

Note: The effects of headloss through the R.C.B. only flowing 1/2 full are neglible considering the final h_L comps on pg 7 and final head comps will be rounded up to nearest 1/10.

c) Pump Pipe Losses



(CASE 4)

EL. 40.0 MAX SUBMERGENCE $51.4 - 40 = 17.4'$

EL. 35.0 MIN PUMPING (CASE 1) $51.4 - 35 = 16.4'$

Pipe Length = $51.4 - 32.0 = 19.4'$

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PLATE F-4

Subject	Walnut Creek Pumping Station	Date JUNE 90
Computed by K. Haas	Checked by	Sheet 5 of 14

Cases 1 + 2 Are Identical

Pipe Head losses are included into Manufacturers pump curves up to 20 inches above Unit. Assume unit height = 50". Total pipe length accounted for equals 50" + 20" = 70" = 5.83 ft

$$V_{pipe} = \left(13{,}333 \text{ gallons/min}\right)\left(1 \text{ ft}^3/7.48 \text{ GAL}\right)\left(\frac{1 \text{ min}}{60 \text{ sec}}\right)\left(\frac{4}{\pi (2.66')^2}\right)$$

$$= 5.34 \text{ ft/s}$$

$$\frac{V^2}{2g} = (5.34)^2/2(32.2) = .4438 \text{ ft}$$

$$R_e = 93.2 \times 10^4 \quad \epsilon/d = 0.0001 \Rightarrow f = 0.019$$

$$H_{Lp} = f \frac{L}{d} \frac{V^2}{2G}$$

$$= 0.019 \left(\frac{19.4 - 5.83}{2.66}\right)(.4438)$$

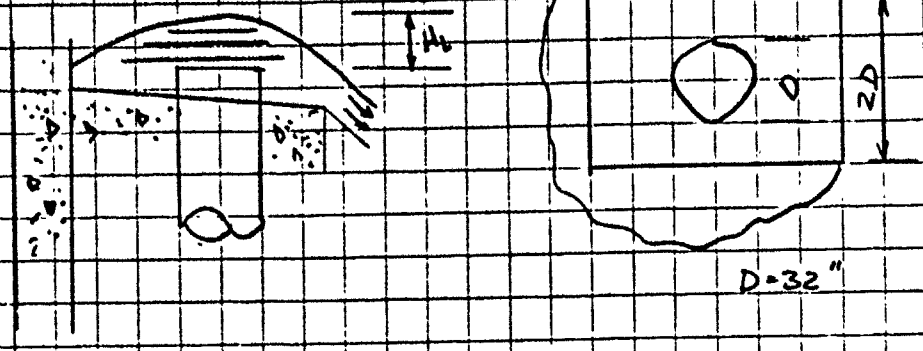
$$H_{Lp} = 0.043 \text{ ft}$$

NCR Form 1 Aug 80 381b

PLATE F-5

Subject	Walnut Creek Pumping Station	Date	June 90
Computed by	K. Hass	Checked by	
		Sheet	6 of 14

d) Exit Losses



REF Flygt System & application engineering data

For Q = 13,333 gpm = .842 m^3/s

$H_{L\ ex.} = 0.57\ M = 1.87\ ft$

NCR Form
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PLATE F-6

Subject	Walnut Creek Pumping Station	Date	June 90
Computed by	K. Hess	Checked by	Sheet 7 of 14

Calculate Total Dynamic Head for Both Cases

$H_{TDH} = H_{STATIC} + H_{L\,ent} + H_{L\,pipe} + H_{L\,DIS.PIPE} + H_{L\,EXT.}$

FOR Min. submergence:

$H_{TDH_1} = 16.4' + 0.0224' + 0.024' + 0.043' + 1.87'$

$H_{TDH_1} = 18.36'$ SAY $18.4'$

FOR MAXIMUM SUBMERGENCE

$H_{TDH_2} = 11.4 + 0.0224 + 0.024 + 0.043 + 1.87'$

$H_{TDH_2} = 13.36'$ SAY $13.4'$

NCR Form 381b
1 Aug 80

PLATE F-7

Subject	Walnut Creek Pumping Station	Date June 90
Computed by K. Hass	Checked by [illegible]	Sheet 8 of 14

Pump Selection for 20,000 gpm station
2 pumps

FLYGT SUBMERSIBLE PROPELLER PUMP (63 KW shaft input
MODEL 7060 700 rpm 4 blade, 20° blade angle
Curve # 63-680.84

Q = 12,300 gpm @ 18.4 ft
Q = 14,200 gpm @ 13.4 ft

Q_{AVE} = 13,250 gpm @ 15.9 ft

Check Pump Specific speed @ BEP

$$N_S = \frac{N Q^{1/2}}{H^{3/4}} = \frac{580 (11200)^{1/2}}{(14.5)^{3/4}} = 8,260 = N_S$$

Check estimated pumping load (input power)

$$Ip = \frac{\text{Water horsepower}}{\eta_{pump}\ \eta_{motor}} = \frac{GPM \times TDH}{3960\ \eta_{pump}\ \eta_{motor}}$$

η_{pump} assumed from the chart
η_{motor} assumed

$$Ip\ ① = \frac{14,200 (13.4)}{3960 (.82) (.85)} = 68.9 Hp\ (51 KW)$$

$$Ip\ ② = \frac{(12,300)(18.4)}{3960 (.82) (.85)} = 82 Hp\ (61 KW)$$

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1 Aug 80 381b

PLATE F-8

FLYGT

PERFORMANCE CURVE

PROD. 7060

CURVE NO 63-700B4

DATE	ISSUE	FREQ	NOMINAL HYDRAULIC-END SPEED	NO. OF BLADES	AVAILABLE BLADE ANGLES
1984-06-05	3	60 Hz	700 RPM	4	EVERY DEG. FROM 5 TO 24 DEG

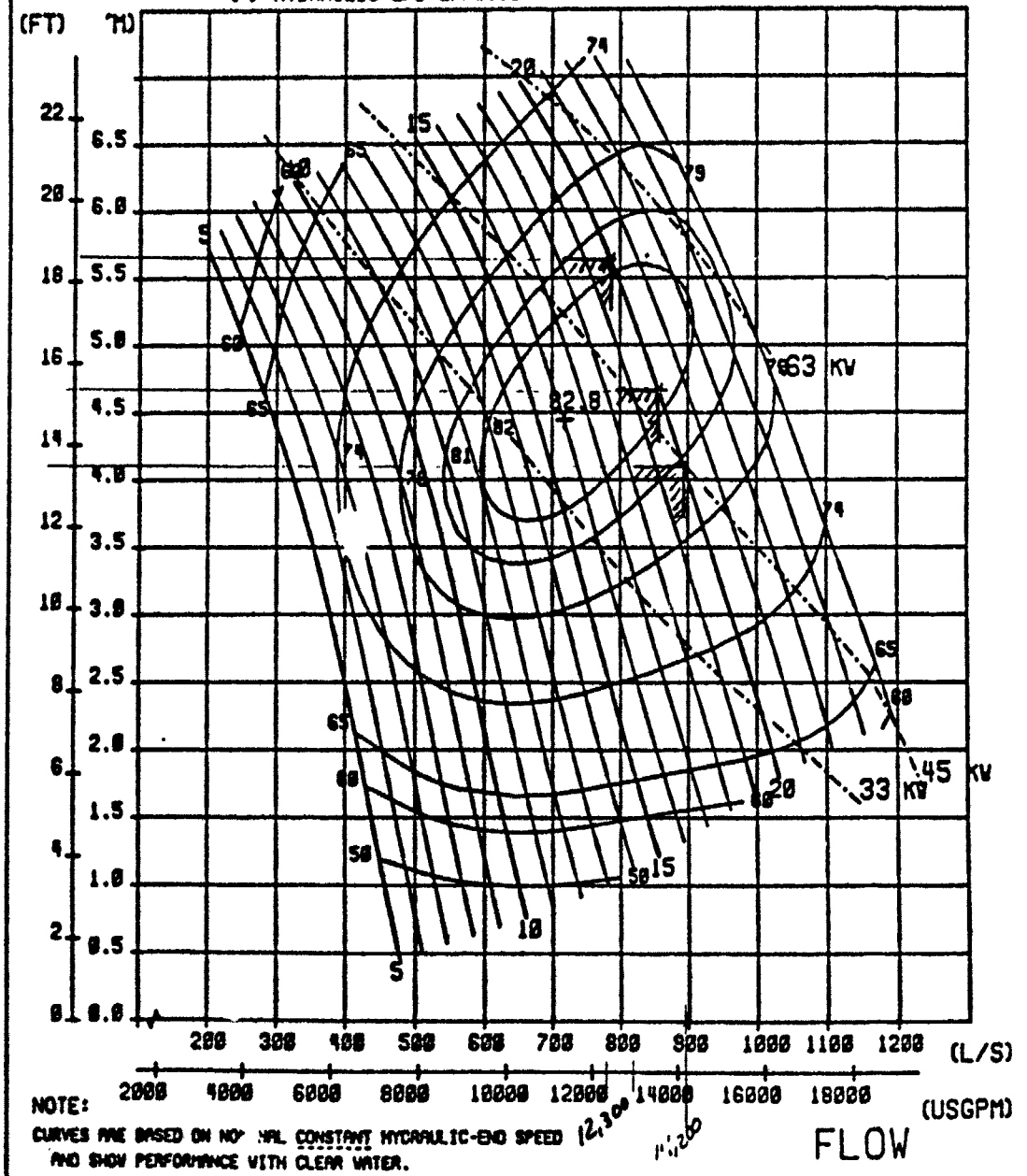
IMPELLER/HUB DIAMETER 550/320 MM

TYPE OF BLADES B

MOTOR	POLES	SHAFT POWER KW	GEARTYPE	GEAR RATIO	GEAR EFFICIENCY (1/1-3/4 LOAD)	RATED SPEED RPM
35-28-1	10	33				700
40-30-1	10	45				695
40-44-1	10	63				700
40-57-1	10	110				700

HEAD (FT) (M)

(-) HYDRAULIC-END EFFICIENCY (%) AND (-.-) POWER LIMITS (ISO-CURVES)



NOTE:

CURVES ARE BASED ON NORMAL CONSTANT HYDRAULIC-END SPEED AND SHOW PERFORMANCE WITH CLEAR WATER.

ALL HYDRAULIC LOSSES UP TO 500 MM. ABOVE THE PUMP/MOTOR TOP ARE INCLUDED

PLATE F-9

Subject	Walnut Creek Pumping STA	Date	June 90
Computed by	KEH	Checked by	Sheet 10 of 14

NPSH REQUIREMENTS

Metric flow: 12,300 GPM @ 18.4' ⇒ 770 l/s @ 5.6 m

= 14,200 GPM @ 13.4' ⇒ 890 l/s @ 4.1 m

Assume NPSH req = 6.0 M = 19.7 ft @ inlet flange

$NPSH_{req} \leq NPSH_{AVAIL.}$

$$19.7 \text{ ft} \leq \frac{p_s - p_v}{\gamma} + H_{\text{below surface}}$$

p_s = P@ water surface = 14.7 PSIA

p_v = Vapor pressure H_2O @ 60°F = 0.2563 PSIA

γ = 62.34 lb/ft³ @ 60°F

H = 35 - 32 = 3'

$$19.7 \leq^{?} \left(\frac{14.7 - 0.2563}{62.34} \times 144\right) + 3'$$

19.7 ≤ 36.3 ∴ OK for 35' min pond level

Min Submergence = 26" or 2'-2" from chart

Actual Submergence = 35-32" = 3'

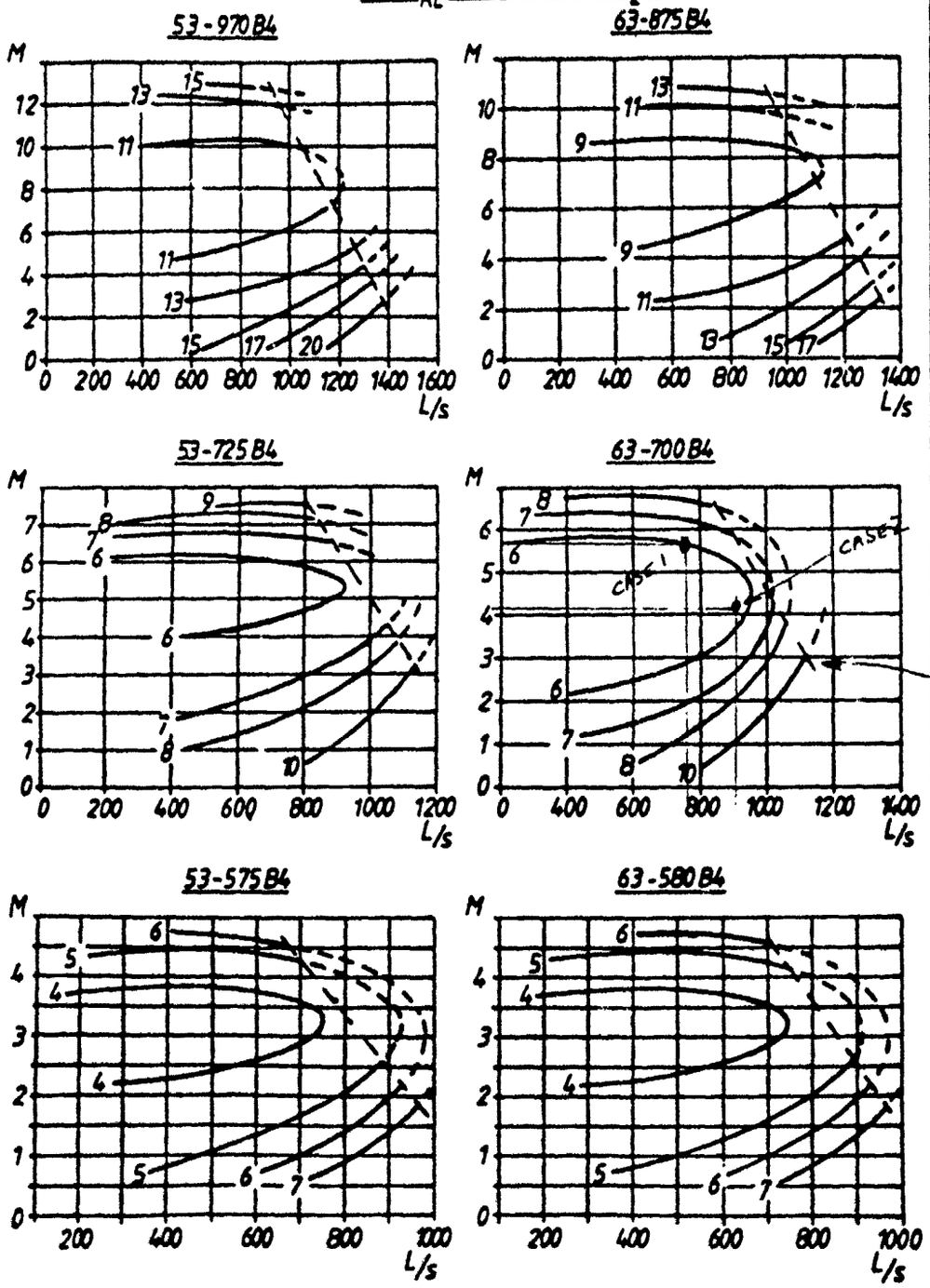
∴ OK for Submergence req.

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1 Aug 80

PLATE F-13

FLYGT	DATE 83 10 10 ISSUE 2	NPSH CURVES	7060

$NPSH_{RE}$ VALUES IN M H_2O



THE NPSH VALUES ARE RELATED TO THE INLET FLANGE.
ALL NPSH LIMIT CURVES ARE VALID FOR OPERATION WITHOUT LOSS IN PERFORMANCE AND NO REDUCTION ON LIFE TIME.

PLATE F-11

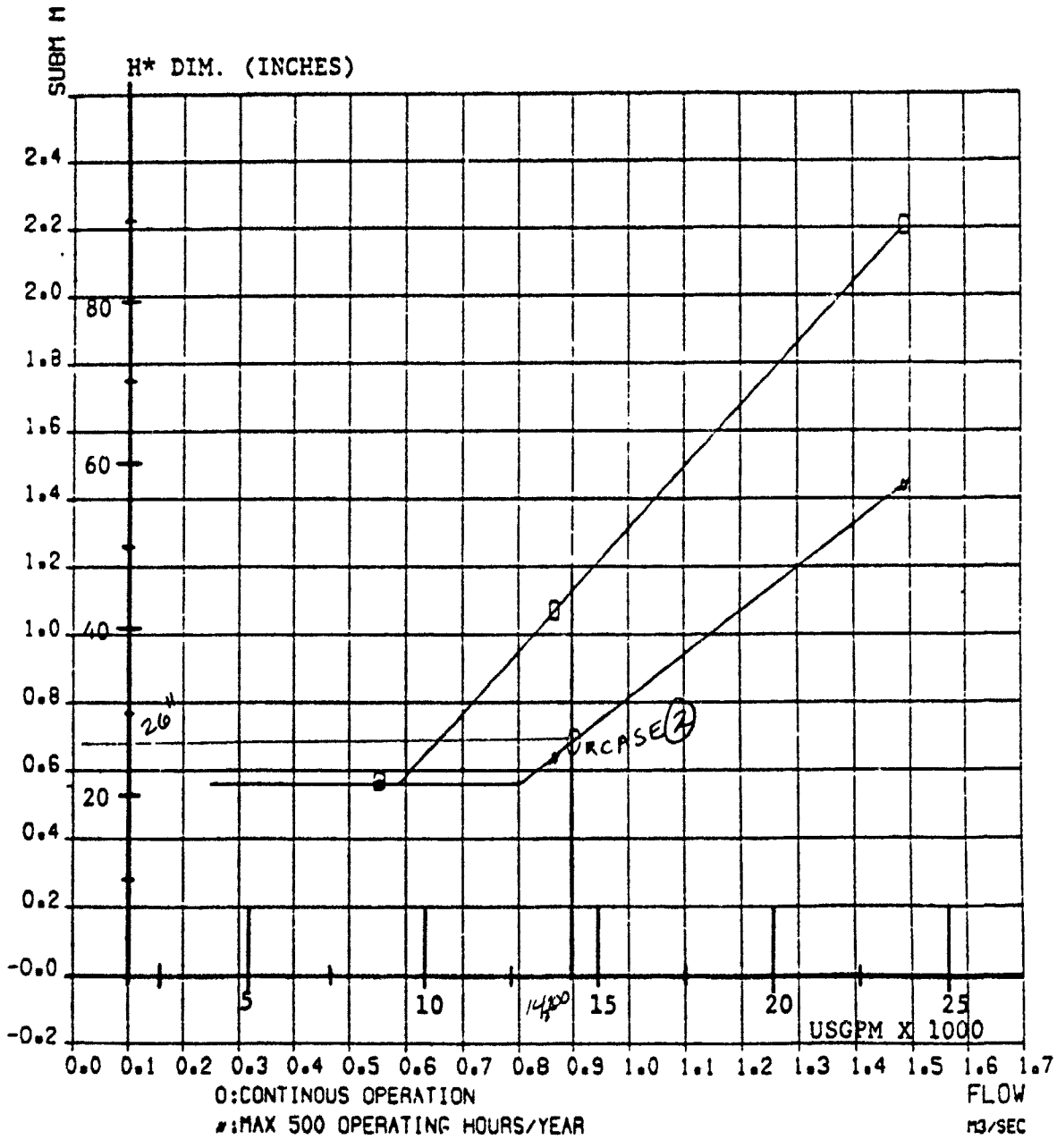
FLYGT

SYSTEM AND APPLICATION ENGINEERING

DIAGRAM: SUBMERGENCE REQUIREMENTS FOR PL 7055/60	ISSUE: 2	DATE: 84-05-23

REQUIRED SUBMERGENCE FOR SUMP DESIGN ACCORDING TO FLYGT TYPE "A","B".

REQUIRED SUBMERGENCE TO PREVENT VORTEXING WHICH WOULD AFFECT THE PERFORMANCE OF THE PUMP. IN SOME INSTANCES ADDITIONAL SUBMERGENCE MAY BE REQUIRED BECAUSE OF NPSH REQUIREMENTS.



0:CONTINOUS OPERATION
#:MAX 500 OPERATING HOURS/YEAR

PLATE F-12

Subject	Walnut Creek Pumping Station	Date June 90
Computed by K. Haas	Checked by	Sheet 13 of 14

Annual Operating Plant

A. Pumping Cost

Assume both pumps on @ Q AVE, H AVG

Q = 13,250

H = 15.9

η pump = 81% efficiencies assumed

η motor = 85%

$$HP_{Average} = \frac{QH}{3960\,\eta_{pump}\,\eta_{motor}} = \frac{(13,250)(15.9)}{3960\,(.81)(.85)} = 77\,HP$$

2 pumps on = 154 HP × .7457 = 115 Kw

CENCRED-HH estimates Less than 1 hour of operation per year or 650,000 gals/year.

$$\text{Pumping \$/yr} = P_{pump\,input} \times \frac{\text{Vol/yr}}{\text{Total pump rate}} \times \frac{0.10\,\$}{\text{Kwhr.}}$$

$$= 115\ Kw \times \frac{650000\ gal/yr}{1.57 \times 10^6\ gal/hr} \times \frac{.10\,\$}{Kwhr} = \$4.70/yr.$$

SAY $5/yr. pumping cost Average

NOTE: Electrical rates and charges are assumed at the time of computing this analysis. Actual demand charges & other factors will be refined as the final power agreement is reviewed by Town Power

NCR Form 1 Aug 80 381b

PLATE F-13

Subject	Walnut Creek Pumping STA	Date	June 90
Computed by	KEH	Checked by	Sheet 14 of 14

B. Pump Testing + Maintenance Cost

Assume 1 hr/Month for each pump for Testing + Maintenance Purposes

Assume 115KW draw for 1 hr each month

$$\text{Test } \$/\text{yr} = \text{KW draw} \times \text{Time/yr} \times \frac{.10}{\text{Kwhr}}$$

$$= 115\text{KW} \times 12\ ^{\text{hr}}/_{\text{yr}} \times .10\ ^{\$}/_{\text{KWHR}}$$

$$= \$138/\text{yr testing}$$

c) KWH for Controls + Heaters

Assume 400 watt Control panel

$$\text{Control } \$/\text{yr} = \text{Control panel power} \times \frac{24\text{ hrs}}{\text{day}} \times \frac{365\text{ days}}{\text{yr}} \times 0.10\ ^{\$}/_{\text{KWHR}}$$

$$= .4\text{KW} \times \frac{24\text{hrs}}{\text{day}} \times 365\text{ days} \times 0.10$$

$$= \$350/\text{year}$$

Annual Energy cost = 5 + 138 + 350

= $493

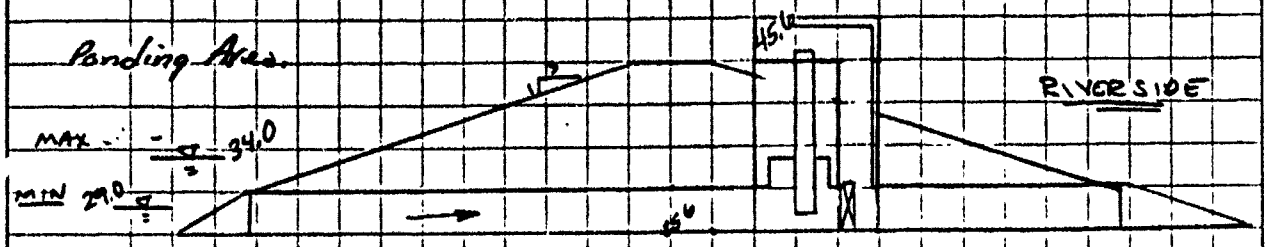
SAY $500/yr. Average

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PLATE F-14

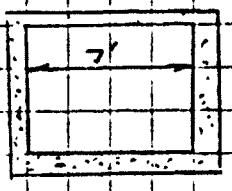
Subject	RACCOON RIVER PUMPING STATION	Date	June 90
Computed by	K Hass	Checked by	RR
		Sheet 1 of 14	

50,000 gpm 3-Pumps



DETERMINE SYSTEM HEAD LOSSES

a) TRASH RACK LOSSES
b) Pipe Losses R.C.B. 5'x7' RCB.
c) Pump pipe losses + static head requirement
d) Exit Losses



Pumping STATION DESIGN Q = 50,000 gpm 3pumps

Applying the 2/3 rule x 50,000 = 33,333 gpm from 2 pumps

Design Q = Each pump discharges 16,666 gpm each

2 cases will be investigated

CASE (1).	Pond at 34.0	Q = 50,000 gpm	111.4	c.f.s.
CASE (2).	Pond at 29.0	Q = 50,000 gpm.	111.4	c.f.s.

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PLATE F-15

Subject	RACCOON RIVER PUMPING STATION	Date June 90
Computed by K. Hass	Checked by RVK	Sheet 2 of 14

2) TRASH RACK LOSSES

∇ 340

$K_{T.R.} = 0.25$



Inlet Headwall

CASE (1)

$V_{T.R.} = Q/A = \frac{111.4 \text{ cfs}}{(5' \times 7')} = 3.18 \text{ f.p.s.}$

$\frac{V^2}{2G} = \frac{(3.18)^2}{2(32.2)} = .157$

$H_{LTR} = K_{T.R.} \frac{V^2}{2G} = 0.25(.157) = 0.039$

$H_{L\ T.R.\ per\ pump} = 0.039'$ ok for 4" spaces w/ 3/8" bars

CASE (2) $V_{TR} = \frac{111.4}{(5 \times 3)} = 7.42 \text{ f.p.s}$

$\frac{V^2}{2G} = \frac{(7.42)^2}{2(32.2)} = 0.85'$

$H_{L\ T.R.} = K_{TR} \frac{V^2}{2G} = 0.25(.85) = 0.21'$ per pump

ok for 4" spaces w/ 3/8" bars

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PLATE F-16

Subject	RACCOON RIVER PUMPING STATION	Date June 90
Computed by K. Hass	Checked by [illegible]	Sheet 3 of 14

B) Pipe Losses

CASE (1) Pipe flowing full.

Use Darcy-Weisbach equation

$$h_L = f \frac{L}{D} \frac{V^2}{2g}$$

$f = 0.025$

$L = 60'$ Area $= 5' \times 7' = 35\ ft^2$

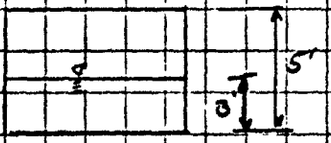
$D_h = 5.83'$ $D_h = \frac{4A}{P} = \frac{4(35)}{(14)+(10)} = 5.83'$

$\frac{V^2}{2g} =$ ... from p. 2

$$h_L = 0.025 \frac{60}{5.83} (.157) = 0.04\ ft$$

CASE 2

Pond @ 29.0



Ref Open Channel Flow
Chow Appendix A

Area $= 3 \times 7 = 21\ ft^2$

Velocity $= 111.4/21 = 5.3\ f/s$

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PLATE F-17

Subject	RACCOON RIVER PUMPING STATION	Date June 90
Computed by K. Hass	Checked by	Sheet 4 of 14

Wetted Perimeter = 3+7+3 = 13'

Hydraulic Radius = R = A/wp = 21/13 = 1.61 ft

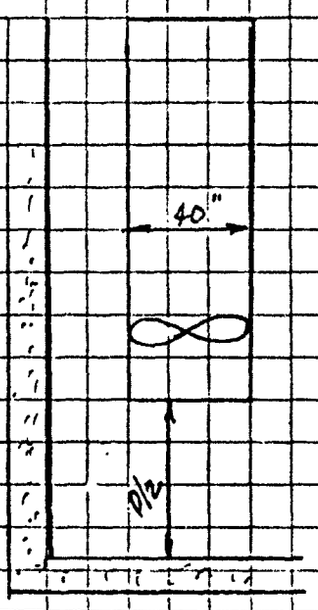
Using Manning EQ

n = 0.013 for Concrete $H_L = S = \left(\frac{nV}{1.49R^{2/3}}\right)^2 L$

$H_L = \left(\frac{(0.013)(5.3)}{1.49\,(1.61)^{2/3}}\right)^2 60'$

$H_L = 0.068'$

c) PUMP PIPE LOSSES



45.6

34.0 max pond

H_{STATIC} CASE ① = 45.6 - 34 = 11.6'

29.0 min. pond 45.6 - 29 = 16.6'

H_{STATIC} CASE ②

26.9

Pipe length = 45.6 - 26.9 = 18.7'

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PLATE F-18

Subject	RACCOON RIVER PUMPING STATION	Date June 90
Computed by K. Hess	Checked by	Sheet 5 of 14

CASES 1+2 Are IDENTICAL

Pipe head losses are included into the Manufacturers pump curves up to 20 inches above the unit. Assume Unit ht = 50". Total pipe length accounted for equals 50" + 20" = 70" = 5.83 ft

$$V_{pipe} = 16.666\ gpm \left(\frac{1\ ft^3}{7.48\ gal}\right)\left(\frac{1\ min}{60\ sec}\right)\left(\frac{4}{\pi (3.33)^2}\right)$$

$V_{pipe} = 4.26$ fps.

$$\frac{V^2}{2G} = (4.26)^2 / 2(32.2) = 0.282$$

R_E 93.2×10^4, $\varepsilon/d = 0.0001 \Rightarrow f = 0.019$
Moody chart

$$H_{LP} = f \frac{L}{d} \frac{V^2}{2G}$$

$$= 0.019 \left(\frac{18.7 - 5.83}{3.33}\right) (0.282)$$

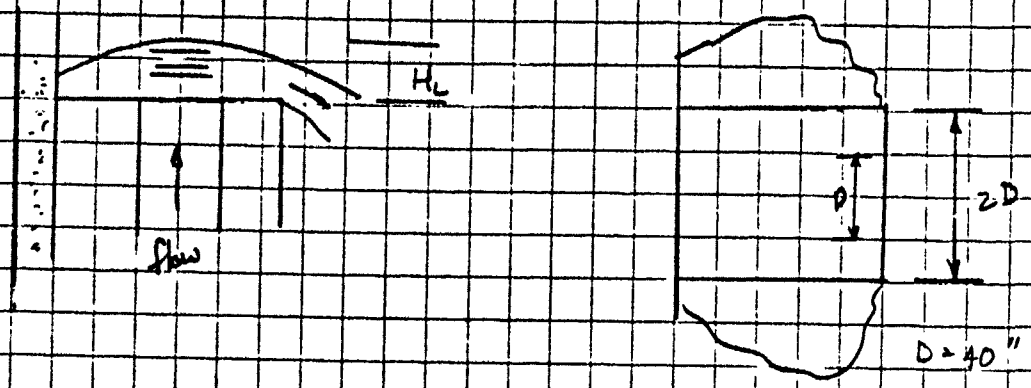
$H_{LP} = 0.0207'$

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PLATE F-19

Subject	RACCOON RIVER PUMPING STATION	Date June 90
Computed by K. Haas	Checked by	Sheet 6 of 14

d) EXIT LOSSES



CASES ①+② ARE IDENTICAL

REF: FLYGT SYSTEM & Application engineering data

FOR Q = 16,666 gpm = 1.052 m^3/s

Flygt PL7080 H_L = .54 m = 1.77'

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1 Aug 80 381b

PLATE F-20

Subject	RACCOON RIVER PUMPING STATION	Date June 90
Computed by KEH	Checked by	Sheet 7 of 14

CALCULATE TOTAL DYNAMIC HEAD

$H_{TDH} = H_{STATIC} + H_{TR} + H_{pipe} + H_{PUMP\ SLOPE} + H_{EXIT}$

FOR MAX SUBMERGENCE

$H_{TDH_1} = 11.6 + 0.039 + 0.04 + 0.0207 + 1.77$

$H_{TDH_1} = 13.46$ SAY 13.5'

FOR MIN SUBMERGENCE

$H_{TDH_2} = 16.6 + 0.21 + 0.068 + 0.0207 + 1.77$

$= 18.67'$ SAY 18.7'

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PLATE F-21

Subject	RACCOON RIVER PUMPING STA	Date June 90
Computed by K. Hazs	Checked by	Sheet 8 of 14

PUMP SELECTION FOR 50,000 gpm STATION
3 pumps

FLYGT SUBMERSIBLE PROPELLER PUMP
MODEL 7080 580RPM 4 BLADE 11° Angle
75 KW motor

Q = 14,000 @ 18.7'
Q = 17,000 @ 13.5

$Q_{average}$ = 15,500 gpm @ 15.98'

$Q_{average}$ is slightly less than the 2/3 requirement of 16,600 gpm per pump. Since this station will not see much use over the life of the project, it is adequate to provide a slightly less than design Q for the STATION. 3 x 15,500 = 46,500 < 50,000 gpm OK

Check Pump specific speed @ B.E.P.

$$N_s = \frac{NQ^{1/2}}{H^{3/4}} = \frac{580\,(23{,}000)^{1/2}}{(16.5)^{3/4}} = 10{,}744 = N_s$$

Check Estimated pumping load (input power)

I_p = Water Horsepower / η_{pump} η_{motor} = $\frac{GPM \times TDH}{3960\ \eta_p\ \eta_m}$

η_{motor} assumed 85%

$$I_p @ \frac{17{,}000(13.5)}{3960\,(.80)(.85)} = 85\ HP\ (64 kw)$$

$$I_p @ \frac{14{,}000(18.7)}{3960\,(.75)(.85)} = 104\ HP\ (77\ KW) \approx 75 KW$$

close enough

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1 Aug 80 381b

PLATE F-22

FLYGT

PERFORMANCE CURVE

PROD. 7080

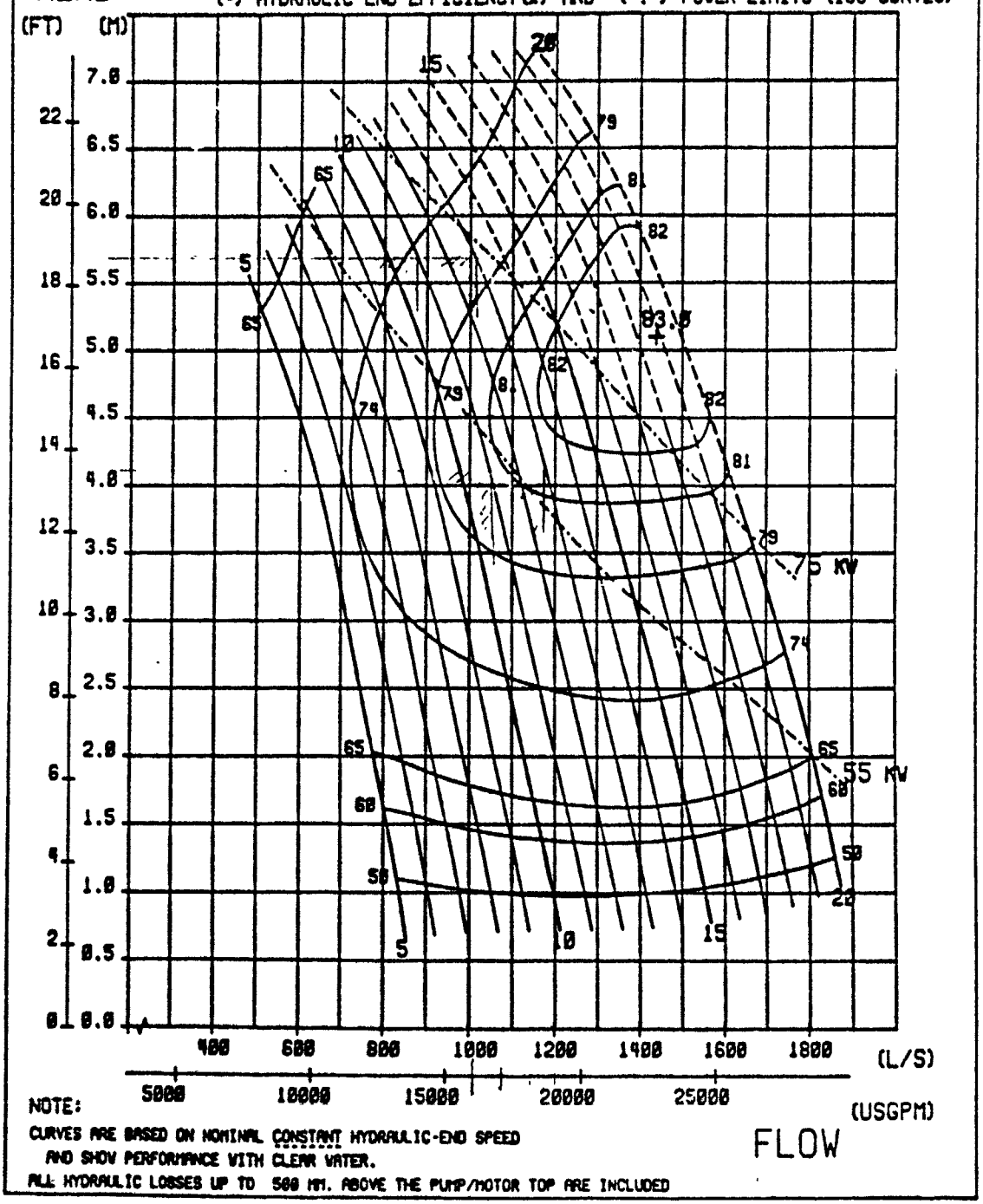
CURVE NO 63-580B4

DATE	ISSUE	FREQ	NOMINAL HYDRAULIC-END SPEED	NO. OF BLADES	AVAILABLE BLADE ANGLES
1984-06-12	3	60 HZ	580 RPM	4	EVERY DEG. FROM 5 TO 20 DEG

IMPELLER/HUB DIAMETER 700/400 MM

TYPE OF BLADES B

MOTOR	POLES	SHAFT POWER	GEARTYPE	GEAR RATIO	GEAR EFFICIENCY (1/1-3/4 LOAD)	RATED SPEED
40-44-3	12	55 KW				580 RPM
40-57-3	12	75				580



NOTE:
CURVES ARE BASED ON NOMINAL CONSTANT HYDRAULIC-END SPEED AND SHOW PERFORMANCE WITH CLEAR WATER.
ALL HYDRAULIC LOSSES UP TO 500 MM. ABOVE THE PUMP/MOTOR TOP ARE INCLUDED

PLATE F-23

Subject	RACCOON RIVER PUMPING STA	Date June 90
Computed by K. Hazs	Checked by AW	Sheet 10 of 14

NPSH REQUIREMENTS

Metric flow 14,000 GPM @ 18.7' ⇒ 883 l/s @ 5.6 m

17,000 GPM @ 13.5 ⇒ 1072 l/s @ 4.1 m

Assume NPSH = GM = 19.7 ft from NPSH curves

$NPSH_{req} \leq NPSH_{AVAIL.}$

$$19.7' \leq \frac{P_a - P_v}{\gamma} + H_{\text{below surface}}$$

P_a = P @ water surface = 14.7 PSIA

P_v = Vapor pressure H_2O 60°F = 0.2563 psia

γ = 62.34 lb/ft³ @ 60°F

H = 29 − 26.9 = 2.1 ft

$$19.7 \leq \left(\frac{14.7 - 0.2563}{62.34} \times 144\right) + 2.1'$$

$19.7 \leq 35.46$ ∴ OK for 29' min pond

Min Submergence from chart = 28" = 2'-4"

Actual submergence 2'-2"

(Close enough at this time)

The Rock Island District has had great success in pumping water for below manufacturers recommendations without vortexing or damage to the pumps.

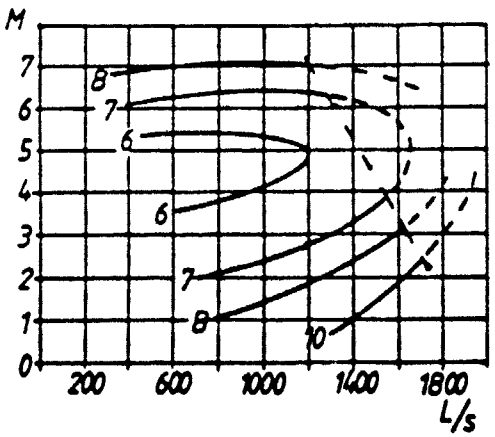
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PLATE F-24

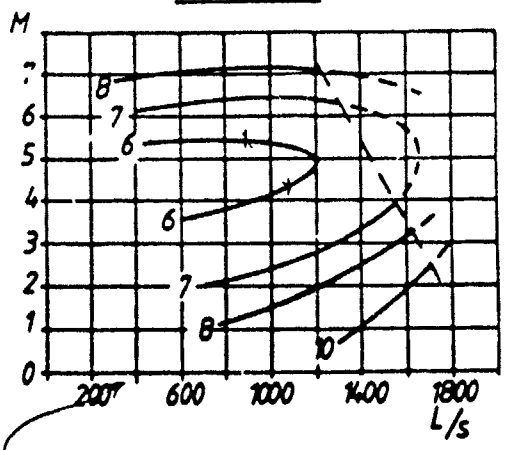
FLYGT	DATE 831010 ISSUE 2	NPSH CURVES	7080(Small)

$NPSH_{RE}$ VALUES IN M H_2O

53-575 B4

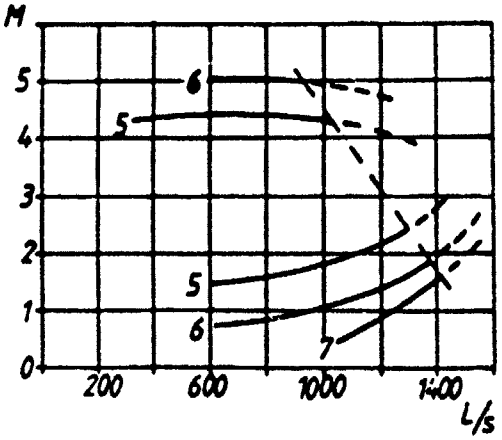


63-580 B4



SELECTED PUMP

53-475B4



THE NPSH VALUES ARE RELATED TO THE INLET FLANGE.
ALL NPSH LIMIT CURVES ARE VALID FOR OPERATION WITHOUT LOSS IN PERFORMANCE AND NO REDUCTION ON LIFE TIME.

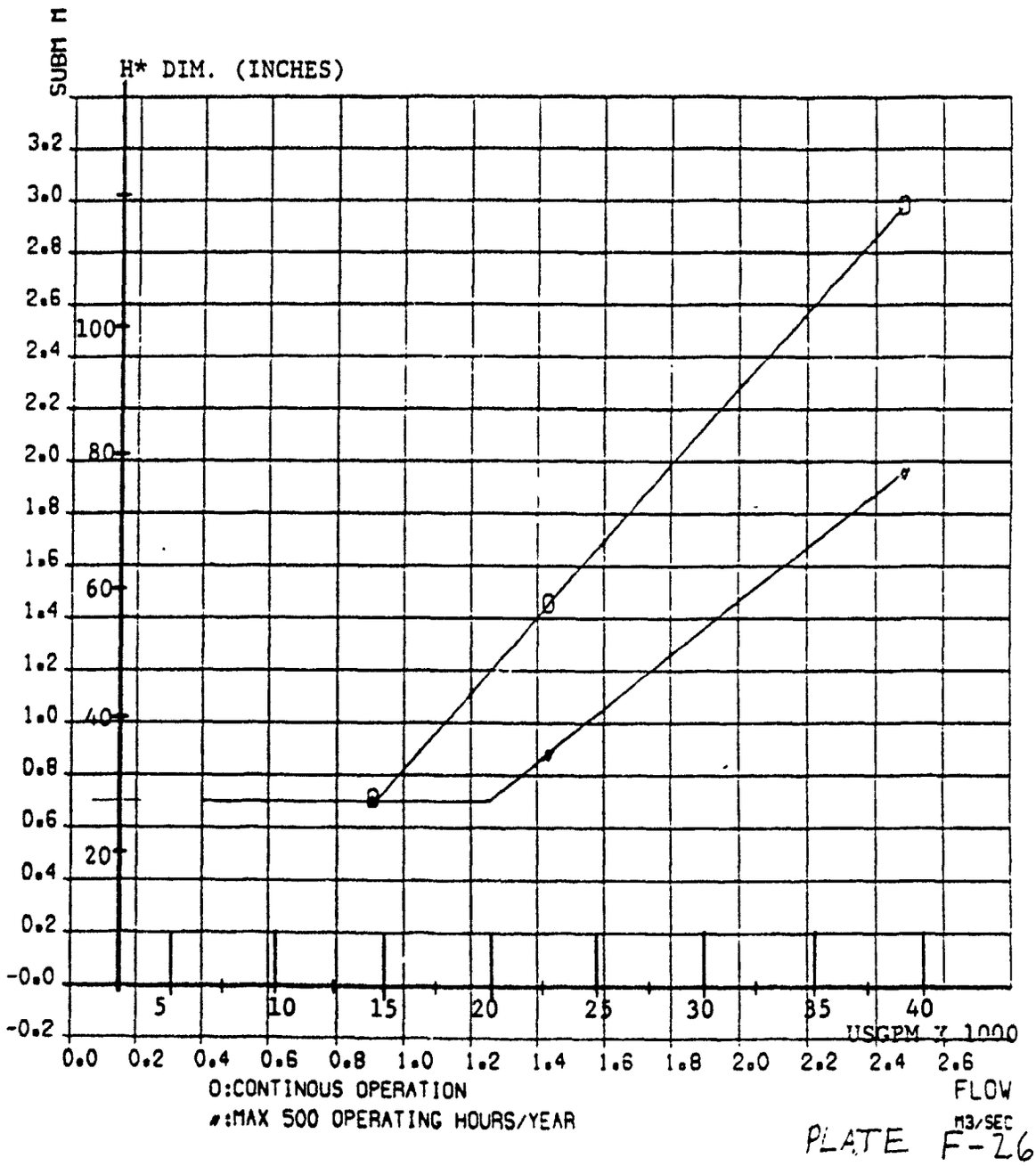
FLYGT

SYSTEM AND APPLICATION ENGINEERING

DIAGRAM: SUBMERGENCE REQUIREMENTS FOR PL 7075/80	ISSUE: 2	DATE: 84-05-23

REQUIRED SUBMERGENCE FOR SUMP DESIGN ACCORDING TO FLYGT TYPE "A","B".

REQUIRED SUBMERGENCE TO PREVENT VORTEXING WHICH WOULD AFFECT THE PERFORMANCE OF THE PUMP. IN SOME INSTANCES ADDITIONAL SUBMERGENCE MAY BE REQUIRED BECAUSE OF NPSH REQUIREMENTS.



O:CONTINOUS OPERATION
#:MAX 500 OPERATING HOURS/YEAR

PLATE F-26

Subject	RACCOON RIVER PUMPING STATION	Date June 90
Computed by K. Hass	Checked by [illegible]	Sheet 13 of 14

Annual Operating Plant

A. Pumping Cost

Assume all three pumps on @ Q Ave and H ave.

Q_{ave} = 15,500 gpm
H_{ave} = 15.98'
η_{pump} = .78
η_{motor} = .85

$$HP_{Average} = \frac{Q\,H}{3960\,\eta_{pump}\,\eta_{motor}} = \frac{15{,}500\,(15.98)}{3960\,(.78)\,(.85)} = 94\,HP$$

3 Pumps on = 3 x 94 = 282 HP = 210 kw

CENCRED-HH estimates 13,730,000 gal/year

$$\text{Pumping \$/yr} = P_{pump\ input} \times \frac{\text{Vol/yr}}{\text{total pump rate}} \times \frac{\$.10}{\text{Kwhr}}$$

$$= 210\,KW \times \frac{13.73 \times 10^6\ gal/yr}{2.79 \times 10^6\ gal/hr} \times \frac{\$.10}{Kwh} = \$103/yr.$$

Average

NOTE: ELECTRICAL RATES AND CHARGES ARE ASSUMED AT THE TIME OF COMPUTING THIS ANALYSIS. ACTUAL DEMAND CHARGES AND OTHER FACTORS WILL BE REFINED AS THE FINAL POWER AGREEMENT IS REVIEWED BY IOWA POWER.

Subject	RACCOON RIVER PUMPING STATION	Date June 90
Compiled by K. Hays	Checked by AR	Sheet 14 of 14

B) Pump testing + Maintenance Cost

Assume 1 hr/month for each pump for testing + Maintenance

Assume 210 kw draw for 1 hr/month

Test $/yr = Kw draw × Time/yr × $.10/kwh

= 210 × 12 hr/yr × $.10

= $252/yr testing

C) KWH for Controls + Heaters

Assume 600 watt Control Panel

$$\text{Control \$/yr} = \text{Control panel power} \times \frac{24\text{hr}}{\text{day}} \times \frac{365\text{day}}{\text{yr}} \times \frac{\$.10}{\text{kwh}}$$

= .6 kw × 24 × 365 × .10 =

= $525/yr.

Annual Energy Cost = $103 + $252 + $525 = $880/yr

SAY $900/yr.

NCR Form 1 Aug 80 381b

PLATE F-28

APPENDIX G

DRAFT LOCAL COOPERATION AGREEMENT

D R A F T

LOCAL COOPERATION AGREEMENT
BETWEEN
THE DEPARTMENT OF THE ARMY
AND
THE CITIES OF WEST DES MOINES, IOWA, AND DES MOINES, IOWA
FOR CONSTRUCTION OF THE
FLOOD CONTROL PROJECT
RACCOON RIVER AND WALNUT CREEK
AT
WEST DES MOINES, IOWA, AND DES MOINES, IOWA

THIS AGREEMENT, entered into this _____ day of _____, 19_____, by and between the DEPARTMENT OF THE ARMY (hereinafter referred to as the "Government"), acting by and through the Assistant Secretary of the Army (Civil Works), and the Cities of WEST DES MOINES, IOWA, and DES MOINES, IOWA (hereinafter referred to as the "Cities"), acting by and through their respective Mayors,

WITNESSETH, that

WHEREAS, construction of the Flood Control Project at West Des Moines - Des Moines (hereinafter referred to as the "Project" as defined in Article I.a. of this agreement), was authorized by the Water Resources Development Act of 1986 (P.L. 99-662, as amended); and

WHEREAS, Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, specifies the cost-sharing requirements applicable to the Project; and

WHEREAS, Section 221 of the Flood Control Act of 1970, Public Law 91-611, as amended, provides that the construction of any water resources project by the Secretary of the Army shall not be commenced until each non-Federal interest has entered into

a written agreement to furnish its required cooperation for the Project; and

WHEREAS, the Cities do not qualify for a reduction of the maximum non-Federal cost share pursuant to the guidelines which implement Section 103(m) of the Water Resources Development Act of 1986, Public Law 99-662, published in 33 C.F.R., Sections 241.1 - 6, entitled "Flood Control Cost-Sharing Requirements Under the Ability to Pay Provision"; and

WHEREAS, the Cities agree to be held jointly and severally responsible for compliance with the terms of this Agreement; and,

WHEREAS, the Cities have the authority and capability to furnish the cooperation hereinafter set forth and are willing to participate in cost-sharing and financing in accordance with the terms of this Agreement;

NOW THEREFORE, the parties agree as follows:

ARTICLE I - DEFINITIONS AND GENERAL PROVISIONS

For purposes of this Agreement:

a. The term "Project" shall mean construction of 4.2 miles of levees and floodwalls, road and railroad closure structures, two pump stations, four ponding areas, and recreation features consisting of 2.8 miles of bike path, ramps, road and railroad crossings, one boat ramp with parking lot, and a scenic vista, along the Raccoon River and Walnut Creek in the Cities of West Des Moines and Des Moines, Iowa.

b. The term "total project costs" shall mean all costs incurred by the Cities and the Government directly related to construction of the Project. Such costs shall include, but not necessarily be limited to, continuing planning and engineering

costs incurred after October 1985; costs of applicable engineering and design; actual construction costs; supervision and administration costs, costs of contract dispute settlements or awards, and the value of lands, easements, rights-of-way, utility and facility alterations or relocations, and dredged material disposal areas provided for the Project by the Cities, but shall not include any costs for betterments, operation, repair, maintenance, replacement or rehabilitation.

c. The term "period of construction" shall mean the time from the advertisement of the first construction contract to the time of acceptance of the Project by the Contracting Officer.

d. The term "Contracting Officer" shall mean the U.S. Army District Engineer for the Rock Island District, or his designee.

e. The term "highway" shall mean any highway, thoroughfare, roadway, street, or other public or private road or way.

f. The term "relocations" shall mean alterations, modifications, lowering or raising in place, and/or new construction related to, but not limited to, existing: railroads, highways, bridges, railroad bridges and approaches thereto, buildings, pipelines, public utilities (such as municipal water and sanitary sewer lines, telephone lines, and storm drains), aerial utilities, cemeteries, and other facilities, structures, and improvements determined by the Government to be necessary for the construction, operation and maintenance of the Project.

g. The term "fiscal year" shall mean one fiscal year of the United States Government, unless otherwise specifically indicated. The Government fiscal year begins on October 1 and ends on September 30.

h. The term "involuntary acquisition" shall mean the acquisition of lands, easements, and rights-of-way by eminent domain.

i. The term "functional portion of the Project" shall mean a completed portion of the Project as determined by the Contracting Officer to be suitable for tender to the Cities to operate and maintain in advance of completion of construction of the entire Project.

j. The term "separable cost of recreation features" shall mean all separable costs incurred by the Cities and the Government for construction of the project recreation features (excluding betterments and operation and maintenance costs). Such recreation costs shall include, but not necessarily be limited to, continuing planning and engineering costs incurred after October 1, 1985; costs of applicable engineering and design; actual construction costs; supervision and administration costs; costs of contract dispute settlements or awards; and the value of any separable lands necessary for access, parking, public health, and safety.

ARTICLE II - OBLIGATIONS OF THE PARTIES

a. The Government, subject to and using funds provided by the Cities and appropriated by the Congress of the United States, shall expeditiously construct the Project (including relocations of railroad bridges and approaches thereto), applying

those procedures usually followed or applied in Federal projects, pursuant to Federal laws, regulations and policies. The Cities shall be afforded the opportunity to review and comment on all contracts, including relevant plans and specifications, prior to the issuance of invitations for bid. The Cities will be afforded the opportunity to review and comment on all modifications and change orders prior to the issuance to the contractor of a Notice to Proceed. The Government will consider the comments of the Cities, but award of contracts, modifications or change orders, and performance of all work on the Project (whether the work is performed under contract or by Government personnel), shall be exclusively within the control of the Government.

b. When the Government determines that the Project or a functional portion of the Project is complete, the Government shall turn the completed Project or functional portion over to the Cities, which shall accept the Project or functional portion and be solely responsible for operating, repairing, maintaining, replacing and rehabilitating the Project or functional portion in accordance with Article VIII hereof.

c. As further specified in Article VI hereof, the Cities shall provide, during the period of construction, a cash contribution of 5 percent of total project costs allocated to structural flood control.

d. As further specified in Article III hereof, the Cities shall provide all lands, easements, rights-of-way, and dredged material disposal areas, and perform all relocations (excluding railroad bridges and approaches thereto) determined by

the Government to be necessary for construction of the Project. At its sole discretion, the Government may perform relocations in cases where it appears that the Cities' contributions will exceed the maximum non-Federal cost share set out in Article VI.f.

e. If the value of the contributions provided under paragraphs c. and d. of this Article represents less than 25 percent of total project costs, the Cities shall provide, during the period of construction, an additional cash contribution in the amount necessary to make its total contribution equal to 25 percent of total project costs.

f. As further specified in Article VI hereof, the Cities shall provide during the period of construction, a cash contribution of 50 percent of total project costs allocated to separable recreation features.

g. No Federal funds may be used to meet the Cities' share of project costs under this Agreement unless the expenditure of such funds is expressly authorized by statute as verified in writing by the granting agency.

h. The Cities agree to participate in and comply with applicable Federal flood plain management and flood insurance programs.

i. The Cities shall prevent encroachment on any of the flood protection structures, including ponding areas, and if ponding areas are impaired, provide substitute storage capacity or equivalent pumping capacity promptly without cost to the United States.

j. No less than once each year the Cities shall inform affected interests of the limitations of the protection afforded

by the Project. The City of Des Moines shall do so by an advertisement in the local newspaper covering all areas protected by the levee. The City of West Des Moines shall do so by publishing the notice once during the month of April in the Official Notice Section of the Western Express, a newspaper in the City of West Des Moines.

k. The Cities shall publicize flood plain information in the area concerned and shall provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the Project.

ARTICLE III - LANDS, FACILITIES, AND PUBLIC LAW 91-646 RELOCATION ASSISTANCE

a. The Cities shall furnish to the Government all lands, easements, and rights-of-way, including suitable borrow and dredged material disposal areas, as may be determined by the Government to be necessary for the construction, operation, and maintenance of the Project, and shall furnish to the Government evidence supporting the Cities' legal authority to grant rights-of-entry to such lands. The necessary lands, easements, and rights-of-way may be provided incrementally, but all lands, easements, and rights-of-way determined by the Government to be necessary for work to be performed under a construction contract must be furnished prior to the advertisement of the construction contract.

b. The Cities shall provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged material disposal areas necessary for construction of the Project.

c. Upon notification from the Government, the Cities shall accomplish or arrange for accomplishment at no cost to the Government all relocations (excluding railroad bridges and approaches thereto) determined by the Government to be necessary for construction of the Project.

d. The Cities shall comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 C.F.R. Part 24, in acquiring lands, easements, and rights-of-way for construction and subsequent operation and maintenance of the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

ARTICLE IV - VALUE OF LANDS AND FACILITIES

a. The value of the lands, easements and rights-of-way to be included in total project costs and credited towards the Cities' share of total project costs will be determined in accordance with the following procedures:

1. If the lands, easements, or rights-of-way are owned by the Cities as of the date the first construction

contract for the Project is awarded, the credit shall be the fair market value of the interest provided to the Government by the Cities at the time of such award. The fair market value shall be determined by an appraisal, to be obtained by the Cities, which has been prepared by a qualified appraiser who is acceptable to both the Cities and the Government. The appraisal shall be reviewed and approved by the Government.

2. If the lands, easements, or rights-of-way are to be acquired by the Cities after the date of award of the first construction contract for the Project, the credit shall be the fair market value of the interest at the time such interest is acquired. The fair market value shall be determined as specified in Article IV.a.1. of this Agreement. If a City pays an amount in excess of the appraised fair market value, it may be entitled to a credit for the excess if the City has secured prior written approval from the Government of its offer to purchase such interest.

3. If a City acquires more lands, easements, or rights-of-way than are necessary for project purposes, as determined by the Government, then only the value of such portions of those acquisitions as are necessary for project purposes shall be included in total project costs and credited towards the City's share.

4 Credit for lands, easements, and rights-of-way in the case of involuntary acquisitions which occur within a one-year period preceding the date this Agreement is signed or which occur after the date this Agreement is signed will be based

on court awards, or on stipulated settlements that have received prior Government approval.

5. Credit for lands, easements, or rights-of-way acquired by the Cities within a five-year period preceding the date this Agreement is signed, or at any time after this Agreement is signed, will also include the actual incidental costs of acquiring the interest, e.g., closing and title costs, appraisal costs, survey costs, attorney's fees, plat maps, and mapping costs, as well as the actual amounts expended for payment of any Public Law 91-646 relocation assistance benefits provided in accordance with the obligations under this Agreement.

b. The costs of relocations which will be included in total project costs and credited towards the Cities' share of total project costs shall be that portion of the actual costs as set forth below, and approved by the Government:

1. Highways and Highway Bridges: Only that portion of the cost as would be necessary to construct substitute bridges and highways to the design standard that the State of Iowa would use in constructing a new bridge or highway under similar conditions of geography and traffic loads.

2. Utilities and Facilities (including railroads): Actual relocation costs, less depreciation, less salvage value, plus the cost of removal, less the cost of betterments. With respect to betterments, new materials shall not be used in any alteration or relocation if materials of value and usability equal to those in the existing facility are available or can be obtained as salvage from the existing

facility or otherwise, unless the provision of new material is more economical. If, despite the availability of used material, new material is used, where the use of such new material represents an additional cost, such cost will not be included in total project costs.

ARTICLE V - CONSTRUCTION PHASING AND MANAGEMENT

a. To provide for consistent and effective communication between the Cities and the Government during the period of construction, the Cities and the Government shall appoint representatives to coordinate on scheduling, plans, specifications, modifications, contract costs, and other matters relating to construction of the Project. The Cities will be informed of any changes in cost estimates.

b. The representatives appointed above shall meet as necessary during the period of construction and shall make such recommendations as they deem warranted to the Contracting Officer.

c. The Contracting Officer shall consider the recommendations of the representatives in all matters relating to construction of the Project, but the Contracting Officer, having ultimate responsibility for construction of the Project, has complete discretion to accept, reject, or modify the recommendations.

ARTICLE VI - METHOD OF PAYMENT

a. The Cities shall provide, during the period of construction, the cash payments required under Article II of this Agreement. Total project costs are presently estimated to be $16,392,000. In order to meet its share, the Cities must provide

a cash contribution presently estimated to be $1,173,000. The dollar amounts set forth in this Article are based upon the Government's best estimates which will reflect projection of costs, price level changes, and anticipated inflation. Such cost estimates are subject to adjustments based upon costs actually incurred and are not to be construed as the total financial responsibilities of the Government and the Cities.

b. The Cities shall provide their required cash contribution in proportion to the rate of Federal expenditures during the period of construction in accordance with the following provisions:

1. For purposes of budget planning, the Government shall notify the Cities by December 1 of the prior budget year of the estimated funds that will be required from the Cities to meet their share of total project costs for the upcoming fiscal year.

2. No later than 60 calendar days prior to the award of the first construction contract, the Government shall notify the Cities of the Cities' share of total project costs, including their share of costs attributable to the Project incurred prior to the initiation of construction, for the first fiscal year of construction. No later than 30 calendar days thereafter, the Cities shall verify to the satisfaction of the Government that they have deposited the requisite amount in an escrow account acceptable to the Government, with interest accruing to the Cities.

3. For the second and subsequent fiscal years of project construction, the Government shall, no later than 60 calendar days prior to the beginning of the fiscal year, notify the Cities of the Cities' share of total project costs for that fiscal year. No later than 30 calendar days prior to the beginning of the fiscal year, the Cities shall make the necessary funds available to the Government through the funding mechanism specified in Article VI.b.2. of this Agreement. As construction of the Project proceeds, the Government shall adjust the amounts required to be provided under this paragraph to reflect actual costs.

4. If at any time during the period of construction the Government determines that additional funds will be needed from the Cities, the Government shall so notify the Cities, and the Cities, no later than 45 calendar days from receipt of such notice, shall make the necessary funds available through the funding mechanism specified in Article VI.b.2. of this Agreement.

c. The Government will draw on the escrow account provided by the Cities such sums as the Government deems necessary to cover contractual and in-house fiscal obligations attributable to the Project as they are incurred, as well as costs incurred by the Government prior to the initiation of construction.

d. Upon completion of the Project and resolution of all relevant contract claims and appeals, the Government shall compute the total project costs and tender to the Cities a final accounting of the Cities' share of total project costs. In the

event the total contribution by the Cities is less than their minimum required share of total project costs, the Cities shall, no later than 90 calendar days after receipt of written notice, make a cash payment to the Government of whatever sum is required to meet their minimum required share of total project costs.

e. In the event the Cities have made cash contributions in excess of 5 percent of total project costs allocated to structural flood control which result in the Cities' having provided more than their required share of total project costs, the Government shall, no later than 90 calendar days after the final accounting is complete, subject to the availability of appropriations, return said excess to the Cities; however, the Cities shall not be entitled to any refund of the 5 percent cash contribution required pursuant to Article II.c. of this Agreement.

f. If the Cities' total contribution under this Agreement (including lands, easements, rights-of-way, and relocations, and dredged material disposal areas provided by the Cities) exceeds 50 percent of total project costs, the Government shall, subject to the availability of appropriations for that purpose, refund the excess to the Cities no later than 90 calendar days after the final accounting is complete.

ARTICLE VII - DISPUTES

Before any party to this Agreement may bring suit in any court concerning an issue relating to this Agreement, such party must first seek in good faith to resolve the issue through

negotiation or other forms of nonbinding alternative dispute resolution mutually acceptable to the parties.

ARTICLE VIII - OPERATION, MAINTENANCE, REPAIR, REPLACEMENT, AND REHABILITATION

a. After the Government has turned the completed Project, or functional portion of the Project, over to the Cities, the Cities shall operate, maintain, repair, replace, and rehabilitate the completed Project, or functional portion of the Project, in accordance with regulations or directions prescribed by the Government.

b. The Cities hereby give the Government a right to enter, at reasonable times and in a reasonable manner, upon land which they own or control for access to the Project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project. If an inspection shows that the Cities for any reason are failing to fulfill their obligations under this Agreement without receiving prior written approval from the Government, the Government will send a written notice to the Cities. If the Cities persist in such failure for 30 calendar days after receipt of the notice, then the Government shall have a right to enter, at reasonable times and in a reasonable manner, upon lands the Cities own or control for access to the Project for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Government shall operate to relieve the Cities of responsibility to meet their obligations as set forth

in this Agreement, or to preclude the Government from pursuing any other remedy at law or equity to assure faithful performance pursuant to this Agreement.

ARTICLE IX - RELEASE OF CLAIMS

The Cities shall hold and save the Government free from all damages arising from the construction, operation, and maintenance of the Project, except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE X - MAINTENANCE OF RECORDS

The Government and the Cities shall keep books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to this Agreement to the extent and in such detail as will properly reflect total project costs. The Government and the Cities shall maintain such books, records, documents, and other evidence for a minimum of three years after completion of construction of the Project and resolution of all relevant claims arising therefrom, and shall make available at their offices at reasonable times, such books, records, documents, and other evidence for inspection and audit by authorized representatives of the parties to this Agreement.

ARTICLE XI - GOVERNMENT AUDIT

The Government shall conduct an audit when appropriate of the Cities' records for the Project to ascertain the allowability, reasonableness, and allocability of their costs for inclusion as credit against the non-Federal share of project costs.

ARTICLE XII - FEDERAL AND STATE LAWS

In acting under its rights and obligations hereunder, the Cities agrees to comply with all applicable Federal and State laws and regulations, including Section 601 of Title VI of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army".

ARTICLE XIII - RELATIONSHIP OF PARTIES

The parties to this Agreement act in an independent capacity in the performance of their respective functions under this Agreement, and neither the Government nor the Cities, acting jointly, are to be considered the officer, agent, or employee of the other.

ARTICLE XIV - OFFICIALS NOT TO BENEFIT

No member of or delegate to the Congress, or resident commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom.

ARTICLE XV - COVENANT AGAINST CONTINGENT FEES

The Cities warrant that no person or selling agency has been employed or retained to solicit or secure this Agreement upon agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the Cities for the purpose of securing business. For breach

or violation of this warranty, the Government shall have the right to annul this Agreement without liability, or, in its discretion, to add to the Agreement or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE XVI - TERMINATION OR SUSPENSION

a. If at any time the Cities fail to make the payments required under this Agreement, the Secretary of the Army shall terminate or suspend work on the Project until the Cities are no longer in arrears, unless the Secretary of the Army determines that continuation of work on the Project is in the interest of the United States or is necessary in order to satisfy agreements with any other non-Federal interests in connection with the Project. Any delinquent payment shall be charged interest at a rate, to be determined by the Secretary of the Treasury, equal to 150 per centum of the average bond equivalent rate of the 13-week Treasury Bills auctioned immediately prior to the date on which such payment became delinquent, or auctioned immediately prior to the beginning of each additional 3-month period if the period of delinquency exceeds 3 months.

b. If the Government fails to receive annual appropriations for the Project in amounts sufficient to meet project expenditures for the then-current or upcoming fiscal year, the Government shall so notify the Cities. After 60 calendar days any party may elect without penalty to terminate this Agreement pursuant to this Article or to defer future performance hereunder; however, deferral of future performance under this Agreement shall not affect existing obligations or

relieve the parties of liability for any obligation previously incurred. In the event that any party elects to terminate this Agreement pursuant to this Article, all parties shall conclude their activities relating to the Project and proceed to a final accounting in accordance with Article VI of this Agreement. In the event that any party elects to defer future performance under this Agreement pursuant to this Article, such deferral shall remain in effect until such time as the Government receives sufficient appropriations or until any party elects to terminate this Agreement.

ARTICLE XVII - NOTICES

a. All notices, requests, demands, and other communications required or permitted to be given under this Agreement shall be deemed to have been duly given if in writing and delivered personally, given by prepaid telegram, or mailed by first-class (postage pre-paid), registered, or certified mail, as follows:

If to the City of West Des Moines:

Mayor of West Des Moines
City Hall
West Des Moines, Iowa 50265

If to the City of Des Moines:

Mayor of Des Moines
City Hall
Des Moines, Iowa 50309

If to the Government:

District Engineer
U.S Army Engineer District, Rock Island
Clock Tower Building, P.O. Box 2004
Rock Island, Illinois 61204-2004

b. A party may change the address to which such communications are to be directed by giving written notice to the other parties in the manner provided in this Article.

c. Any notice, request, demand, or other communication made pursuant to this Article shall be deemed to have been received by the addressee at such time as it is personally delivered or seven calendar days after it is mailed, as the case may be.

ARTICLE XVIII - CONFIDENTIALITY

To the extent permitted by the laws governing each party, the parties agree to maintain the confidentiality of exchanged information when requested to do so by the providing party.

ARTICLE XIX - SECTION 902 PROJECT COST LIMITS

The Cities have reviewed the provisions set forth in Section 902 of P.L. 99-662, as amended, and understand that Section 902 establishes a maximum construction cost for the Project. For purposes of this Agreement, the Section 902 cost limit is $21,920,000 as calculated on 31 May 1990. This amount shall be adjusted to allow for appropriate increases for inflation and changes in the project cost as provided in Section 902. Should this cost maximum be reached, no additional funds may be expended on the Project until additional authority is obtained from Congress.

ARTICLE XX - HAZARDOUS SUBSTANCES

a. After execution of this Agreement and upon direction by the Contracting Officer, the Cities shall perform, or cause to be performed, such environmental investigations as are determined necessary by the Government or the Cities to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, on lands necessary for Project construction, operation, and maintenance. All actual costs incurred by the Cities which are properly allowable and allocable to performance of any such environmental investigations shall be included in total project costs and cost-shared as a construction cost in accordance with Public Law 99-662.

b. In the event it is discovered through an environmental investigation or other means that any lands, easements, rights-of-way, or disposal areas to be acquired or provided for the Project contain any hazardous substances regulated under CERCLA, the Cities and the Government shall provide prompt notice to each other, and the Cities shall not proceed with the acquisition of lands, easements, rights-of-way, or disposal areas until mutually agreed.

c. The Government and the Cities, shall determine whether to initiate construction of the Project, or if already in construction, to continue with construction of the Project, or to terminate construction of the Project for the convenience of the

Government in any case where hazardous substances regulated under CERCLA are found to exist on any lands necessary for the Project. Should the Government and the Cities determine to proceed or continue with construction after considering any liability that may arise under CERCLA, as between the Government and the Cities, the Cities shall be responsible for any and all necessary clean up and response costs, to include the costs of any studies and investigations necessary to determine an appropriate response to the contamination. Such costs shall not be considered a part of total project costs as defined in this Agreement. In the event the Cities fail to provide any funds necessary to pay for clean up and response costs or to otherwise discharge their responsibilities under this paragraph upon direction by the Government, the Government may either terminate or suspend work on the Project or proceed with further work as provided in Article XVI.

d. The Cities and the Government shall consult with each other under the Construction Phasing and Management Article of this Agreement to assure that responsible parties bear any necessary clean up and response costs as defined in CERCLA. Any decision made pursuant to paragraph c. of this Article shall not relieve any party from any liability that may arise under CERCLA.

e. The Cities shall operate, maintain, repair, replace, and rehabilitate the Project in a manner so that liability will not arise under CERCLA.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement, which shall become effective upon the date it is signed by the Assistant Secretary of the Army (Civil Works).

THE DEPARTMENT OF THE ARMY

BY: _____
ROBERT W. PAGE
Assistant Secretary of
the Army (Civil Works)

DATE: _____

THE CITY OF WEST DES MOINES, IOWA

BY: _____
GEORGE M. MILLS
Mayor

DATE: _____

THE CITY OF DES MOINES, IOWA

By _____
PAT DORRIAN
Mayor

DATE: _____

ADDENDUM TO LOCAL COOPERATION AGREEMENT
BETWEEN
THE DEPARTMENT OF THE ARMY
AND
THE CITIES OF WEST DES MOINES AND DES MOINES, IOWA
FOR CONSTRUCTION OF THE FLOOD CONTROL PROJECT
AT WEST DES MOINES AND DES MOINES, IOWA

CERTIFICATION REGARDING LOBBYING

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

THE CITY OF WEST DES MOINES, IOWA	THE CITY OF DES MOINES, IOWA
By _____	By _____
Title: _____	Title: _____
Date: _____	Date: _____

DISCLOSURE OF LOBBYING ACTIVITIES

Approved by OMB
0348-0046

Complete this form to disclose lobbying activities pursuant to 31 U.S.C. 1352
(See reverse for public burden disclosure.)

1. Type of Federal Action:	2. Status of Federal Action:	3. Report Type:
☐ a. contract b. grant c. cooperative agreement d. loan e. loan guarantee f. loan insurance	☐ a. bid/offer/application b. initial award c. post-award	☐ a. initial filing b. material change For Material Change Only: year _____ quarter _____ date of last report _____

4. Name and Address of Reporting Entity:	5. If Reporting Entity in No. 4 is Subawardee, Enter Name and Address of Prime:
☐ Prime ☐ Subawardee Tier _____, *if known*: Congressional District, *if known*:	Congressional District, *if known*:
6. Federal Department/Agency:	7. Federal Program Name/Description: CFDA Number, *if applicable*: _____
8. Federal Action Number, *if known*:	9. Award Amount, *if known*: $
10. a. Name and Address of Lobbying Entity (*if individual, last name, first name, MI*):	b. Individuals Performing Services (*including address if different from No. 10a*) (*last name, first name, MI*):

(*attach Continuation Sheet(s) SF-LLL-A, if necessary*)

11. Amount of Payment (*check all that apply*):	13. Type of Payment (*check all that apply*):
$ _____ ☐ actual ☐ planned	☐ a. retainer ☐ b. one-time fee ☐ c. commission ☐ d. contingent fee ☐ e. deferred ☐ f. other; specify: _____
12. Form of Payment (*check all that apply*): ☐ a. cash ☐ b. in-kind; specify: nature _____ value _____	

14. Brief Description of Services Performed or to be Performed and Date(s) of Service, including officer(s), employee(s), or Member(s) contacted, for Payment Indicated in Item 11:

(*attach Continuation Sheet(s) SF-LLL-A, if necessary*)

15. Continuation Sheet(s) SF-LLL-A attached: ☐ Yes ☐ No

16.	
Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when this transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.	Signature: _____ Print Name: _____ Title: _____ Telephone No.: _____ Date: _____

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INSTRUCTIONS FOR COMPLETION OF SF-LLL, DISCLOSURE OF LOBBYING ACTIVITIES

This disclosure form shall be completed by the reporting entity, whether subawardee or prime Federal recipient, at the initiation or receipt of a covered Federal action, or a material change to a previous filing, pursuant to title 31 U.S.C. section 1352. The filing of a form is required for each payment or agreement to make payment to any lobbying entity for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with a covered Federal action. Use the SF-LLL-A Continuation Sheet for additional information if the space on the form is inadequate. Complete all items that apply for both the initial filing and material change report. Refer to the implementing guidance published by the Office of Management and Budget for additional information.

1. Identify the type of covered Federal action for which lobbying activity is and/or has been secured to influence the outcome of a covered Federal action.

2. Identify the status of the covered Federal action.

3. Identify the appropriate classification of this report. If this is a followup report caused by a material change to the information previously reported, enter the year and quarter in which the change occurred. Enter the date of the last previously submitted report by this reporting entity for this covered Federal action.

4. Enter the full name, address, city, state and zip code of the reporting entity. Include Congressional District, if known. Check the appropriate classification of the reporting entity that designates if it is, or expects to be, a prime or subaward recipient. Identify the tier of the subawardee, e.g., the first subawardee of the prime is the 1st tier. Subawards include but are not limited to subcontracts, subgrants and contract awards under grants.

5. If the organization filing the report in item 4 checks "Subawardee", then enter the full name, address, city, state and zip code of the prime Federal recipient. Include Congressional District, if known.

6. Enter the name of the Federal agency making the award or loan commitment. Include at least one organizational level below agency name, if known. For example, Department of Transportation, United States Coast Guard.

7. Enter the Federal program name or description for the covered Federal action (item 1). If known, enter the full Catalog of Federal Domestic Assistance (CFDA) number for grants, cooperative agreements, loans, and loan commitments.

8. Enter the most appropriate Federal identifying number available for the Federal action identified in item 1 (e.g., Request for Proposal (RFP) number; Invitation for Bid (IFB) number; grant announcement number; the contract, grant, or loan award number; the application/proposal control number assigned by the Federal agency). Include prefixes, e.g., "RFP-DE-90-001."

9. For a covered Federal action where there has been an award or loan commitment by the Federal agency, enter the Federal amount of the award/loan commitment for the prime entity identified in item 4 or 5.

10. (a) Enter the full name, address, city, state and zip code of the lobbying entity engaged by the reporting entity identified in item 4 to influence the covered Federal action.

    (b) Enter the full names of the individual(s) performing services, and include full address if different from 10 (a). Enter Last Name, First Name, and Middle Initial (MI).

11. Enter the amount of compensation paid or reasonably expected to be paid by the reporting entity (item 4) to the lobbying entity (item 10). Indicate whether the payment has been made (actual) or will be made (planned). Check all boxes that apply. If this is a material change report, enter the cumulative amount of payment made or planned to be made.

12. Check the appropriate box(es). Check all boxes that apply. If payment is made through an in-kind contribution, specify the nature and value of the in-kind payment.

13. Check the appropriate box(es). Check all boxes that apply. If other, specify nature.

14. Provide a specific and detailed description of the services that the lobbyist has performed, or will be expected to perform, and the date(s) of any services rendered. Include all preparatory and related activity, not just time spent in actual contact with Federal officials. Identify the Federal official(s) or employee(s) contacted or the officer(s), employee(s), or Member(s) of Congress that were contacted.

15. Check whether or not a SF-LLL-A Continuation Sheet(s) is attached.

16. The certifying official shall sign and date the form, print his/her name, title, and telephone number.

Public reporting burden for this collection of information is estimated to average 30 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Office of Management and Budget, Paperwork Reduction Project (0348-0046), Washington, D.C. 20503.

DISCLOSURE OF LOBBYING ACTIVITIES
CONTINUATION SHEET

Approved by
0348-0046

Reporting Entity: _____ **Page** _____ **of** _____

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August 14, 1990

Colonel John R. Brown
U.S. Army Engineer District
Clock Tower Building
P.O. Box 2004
Rock Island, Illinois 61204-2004

Dear Colonel Brown:

RE: STATEMENT OF FINANCIAL CAPABILITY
FLOOD-CONTROL PROJECT
RACCOON RIVER AND WALNUT CREEK

The City of Des Moines, Iowa is a municipal corporation chartered by the State of Iowa. The City has the legal authority to enter into the Local Cooperation Agreement and to fulfill all financial obligations for completion of the project. The City understands that the current cost estimate for the entire project is $16,392,000.00. Of this, the Des Moines share is $1,117,400.00 ($281,900.00 cash and $835,500.00 for right-of-way and relocation costs).

It is the City's intention to finance its share of project costs through the issuance of general obligation bonds. This funding source will be available to meet the City's requirements--as shown on the attached schedule of project expenditures. Enclosed, also, is a copy of the City's latest comprehensive Annual Financial Report.

The City Council has reviewed the Local Cooperation Agreement (LCA) and has found its provisions acceptable. The City strongly desires to proceed with the flood-protection project.

If further information is needed, please do not hesitate to contact our office.

Sincerely,

John P. Dorrian
Mayor

JPD:MMK:bhh

Encl.

CITY OF DES MOINES
MAYOR JOHN P DORRIAN
CITY HALL
EAST FIRST AND LOCUST
DES MOINES, IOWA 50309
(515) 283 4944
ALL-AMERICA CITY 1949 1976 1981

CITY OF DES MOINES

PROJECT FUNDING

FISCAL YEAR 1992 CONSTRUCTION START

	Estimated Funding Requirements		
Fiscal Year	Cash	LERRD[1]	Total
1992	$ 0	$ 0	$ 0
1993	$ 0	$474,000	$ 474,000
1994	$ 50,000	$200,000	$ 250,000
1995	$100,000	$154,500	$ 254,500
1996	$131,900	$ 7,000	$ 138,900
Totals	$281,900	$835,000	$1,117,400[2]

CITY OF DES MOINES

BOND SALES FOR ABOVE PROJECT

Year	Bonds
1991-92	$ 410,000
1992-93	$ 440,000
1993-94	$ 410,000
Total	$1,260,000

[1] Lands, Easements, Relocations, Rights-of-way, Damages

[2] Project financing to be obtained through issuance of General Obligation Bonds in 1992, 1993, and 1994. Amount of bond issue specifically allocated for project purposes is $1,260,000, which will be available to meet the construction schedule.

CITY OF WEST DES MOINES
ADMINISTRATION

August 6, 1990

Colonel John R. Brown
U.S. Army Engineer District
Clock Tower Building
P.O. Box 2004
Rock Island, Illinois 61204-2004

RE: STATEMENT OF FINANCIAL CAPABILITY, Flood Control Project, Raccoon River and Walnut Creek

Dear Colonel Brown:

The City of West Des Moines, Iowa is a municipal corporation chartered by the State of Iowa. The City has the legal authority to enter into the Local Cooperation Agreement and to fulfill all financial obligations for completion of the project. The City understands that the current cost estimate for the entire project is $16,392,000. Of this, the West Des Moines share is $3,081,100, ($891,100 cash and $2,190,000 for right-of-way and relocation costs).

It is the City's intention to finance its share of project costs through the issuance of general obligation bonds. This funding source will be available to meet the City's requirements as shown on the attached schedule of project expenditures. Enclosed is a schedule of the City's total outstanding bonds and remaining bonding capacity. Also enclosed is a prospectus of the City's most recent bond sale (March 1, 1990 issue) in which the City maintained it's Moody's rating of Aa.

The City Council has review the Local Cooperation Agreement (LCA) and has found its provisions acceptable. The City strongly desires to proceed with the flood protection project. If further information is needed, please do not hesitate to contact my office.

Sincerely yours,

George M. Mills

George M. Mills
Mayor

GMM:mr
Enclosures

City of West Des Moines
PROJECT FUNDING
FY 1992 Construction Start
(Amount in thousands of dollars)

Fiscal Year	Estimated Funding Requirements Cash	LERRD *1	Total	
1992	0	600.	600.	
1993	158.4	768.	926.4	
1994	296.0	405.	701.0	
1995	419.6	400.	819.6	
1996	17.1	17.	34.1	
	891.1	2190.0	3081.1	*2

*1 Lands, Easements, Relocations, Rights-of-way, Damages

*2 Project financing to be obtained through issuance of General Obligation Bonds which will be available to meet the construction schedule. A portion of the necessary resources was included in a March, 1990 General Obligation bond issue.

CITIES OF DES MOINES AND WEST DES MOINES, IOWA
LOCAL FLOOD PROTECTION PROJECT

FINANCING PLAN OUTLINE

The cities of Des Moines and West Des Moines, Iowa, non-Federal sponsors of the Local Flood Protection Project, are capable of meeting their cost sharing and other obligations as required under the terms of the Local Cooperation Agreement.

Uses of Funds	Amounts		Comment
	Des Moines	W. Des Moines	
Land Acquisition and Relocation	$ 835,500	$2,190,000	Required real estate acquisition, relocations and associated costs.
Cash Contribution	$ 281,900	$ 891,100	Non-Federal cash requirements during construction.
Annual Operation and Maintenance	$ 7,000	$ 27,000	Normal operation & maintenance of completed flood control project.
Sources of Funds			
General Obligation (GO) 1/ Bonds Issued by the Respective Cities	$1,117,400	$3,081,100	Bonds will be issued to meet financial requirements as displayed on the Attached schedule.
Annual Budget Appropriations	$ 7,000	$ 27,000	Normal budget procedures for public works maintenance.

1/ Both non-Federal sponsors have ample remaining bonding capacities. Bond issuances to meet financing requirements pose no fiscal difficulty for either sponsor.

DES MOINES AND WEST DES MOINES, IOWA

SCHEDULE OF SOURCES AND UED OF NON-FEDERAL FUNDS

	Financing Sources		Annual Cash Requirement		Ending
	Beginning Balance	Annual Funding	LERRD	Cash Contribution	Fund Balance
FY1992 FUNDING SOURCES:					
Des Moines GO Bond Issue	0	$ 410,000	0	0	$ 410,000
W. Des Moines GO Bond Issue	$2,000,000 1/	0	$ 600,000	0	$1,400,000
FY1993 FUNDING SOURCES:					
Des Moines GO Bond Issue	$ 410,000	$ 440,000	$ 474,000	0	$ 376,000
W. Des Moines GO Bond Issue	$1,400,000	0	768,000	$ 158,400	$ 473,600
FY1994 FUNDING SOURCES:					
Des Moines GO Bond Issue	$ 376,000	$ 410,000	$ 200,000	$ 50,000	$ 536,000
W. Des Moines GO Bond Issue	$ 473,600	$ 227,400	$ 405,000	$ 296,000	0
FY1995 FUNDING SOURCES:					
Des Moines GO Bond Issue	$ 536,000	0	$ 154,500	$ 100,000	$ 281,500
W. Des Moines GO Bond Issue	0	$ 819,600	$ 400,000	$ 419,600	0
FY1996 FUNDING SOURCES:					
Des Moines GO Bond Issue	$ 281,500	0	$ 7,000	$ 131,900	$ 142,600
W. Des Moines GO Bond Issue	0	$ 34,100	$ 17,000	$ 17,100	0
Totals:					
Des Moines			$ 835,500	$ 281,900	
West Des Moines			$2,190,000	$ 891,000	

1/ Indicated portion of 1990 Bond Issue Allocated for project purposes.

Des Moines - West Des Moines Flood Protection
Total Project Funding
Fiscal Year 1992 Construction Start
(Amount in Thousands of Dollars)

	Federal	Non-Federal				Total Federal and Non-Federal
		Cash	LERRD*	Cash	LERRD*	& Total
Costs Thru FY91	1,200.0	0	0	0	0	1,200.0
FY 1992	600.0	0	600.0	0	0	1,200.0
FY 1993	450.0	158.4	768.0	0	474.0	1,850.4
FY 1994	3,000.0	296.0	405.0	50.0	200.0	3,951.0
FY 1995	5,400.0	419.6	400.0	100.0	154.5	6,474.1
FY 1996	1,543.5	17.1	17.0	131.9	7.0	1,716.5
TOTALS	$12,193.5	891.1	2,190.0	281.9	835.5	16,392.0

* Lands, Easements, Relocations, Rights-of-Way, Damages

DISTRICT COMMANDER'S ASSESSMENT OF NON-FEDERAL SPONSORS' FINANCING CAPABILITY

The Financing Plans presented by the Cities of Des Moines and West Des Moines, Iowa have been reviewed and are considered sufficient to participate in the construction of the Local Flood Projection Project. Based upon information received from the non-Federal sponsors, it is reasonable to expect that sufficient funds will be available to satisfy the non-Federal sponsors' financial obligations for the project.

John R. Brown
Colonel, Corps of Engineers
District Engineer

APPENDIX H

ENVIRONMENTAL ASSESSMENT

ENVIRONMENTAL ASSESSMENT

FLOODWALL REALIGNMENT
OF THE
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA
FLOOD CONTROL PROJECT

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ENVIRONMENTAL ASSESSMENT
FOR
FLOODWALL REALIGNMENT
OF THE
RACCOON RIVER AND WALNUT CREEK
WEST DES MOINES - DES MOINES, IOWA
FLOOD CONTROL PROJECT

INTRODUCTION

The U.S. Army Corps of Engineers, Rock Island District is currently developing the design memorandum for the West Des Moines-Des Moines, Iowa flood control project. Past studies have included a 1975 feasibility report with Final Environmental Impact Statement (FEIS). A General Reevaluation Report with Final Supplement No.1 to the FEIS updating the earlier study was completed in July 1989. Part of the reevaluation study proposed running a floodwall along the west side of 63rd Street near Walnut Creek. It is now proposed to place the floodwall along the east side of 63rd Street. This environmental assessment (EA) addresses the proposed realignment.

I. PURPOSE AND NEED FOR ACTION.

The purpose, of this project as a whole, is to provide flood protection and a recreation plan to the cities of West Des Moines and Des Moines, Iowa which have experienced flood damages from the local streams.

The realignment of the floodwall from the west side to the east side of 63rd Street along Walnut Creek would be done to lessen construction impacts and floodwall obstruction to businesses along the west side of the street. It would also better accommodate planned future highway construction along 63rd Street. The realignment would have little effect on the overall level of flood protection originally afforded by the project.

II. PROJECT DESCRIPTION.

The total project, as described in the General Reevaluation Report, includes construction of 4.2 miles of levees and floodwalls. It runs along approximately 10,000 feet of the right bank of Walnut Creek, 11,100 feet of the left bank of the Raccoon River, and 1,000 feet of the left bank of Jordan Creek.

Auxiliary features of the project include 4 road closures, 4 railroad closures, 2 pump stations, 3 road ramps over the levee, 6 ramps over the levee, 2 relocated access roads, 4 ponding areas, 2 borrow sites, 2.8 miles of bike paths, and a single lane boat ramp with parking lot.

It is proposed to realign 1854 feet of floodwall from the west side to the east side of 63rd Street near Walnut Creek. Instead of crossing 63rd Street south of Grand Avenue, the floodwall will continue along 63rd to just north of

Ashworth Road. From here it crosses 63rd and runs to Hoak Drive, where it continues along the originally proposed alignment.

Plate H-1 shows both the old and new alignments. The plates found in the main report show the total project alignment as well as typical cross sections.

The placement of the floodwall on the east side of 63rd Street will encroach upon the floodway. Such encroachment has the ability to restrict flows at the 100-year flood level and thereby raise water levels immediately upstream of the restriction. Bridges on Grand Avenue and 63rd Street currently restrict flows during periods of high water. To compensate for floodwall encroachment, the openings beneath these bridges would be cleaned out and maintained. With such maintenance there would be no net increase to flow restrictions.

III. ALTERNATIVES.

A. No Action. With this alternative there would be no project construction. No action was deemed undesirable because it did not aleviate flooding problems.

B. Floodwall Along the West Side of 63rd Street (No Change). With this alternative there would be no change in the selected plan as listed in the General Reevaluation Report. The floodwall would continue along the west side of 63rd street.

C. Floodwall Along the East Side of 63rd Street. This alternative is described under the Project Description. It lessens obstructions to local businesses and any future highway improvements, and is the preferred alternative.

IV. AFFECTED ENVIRONMENT.

The floodwall along 63rd Street would be placed 6 feet from the highway. The area consists of various short grasses and forbs. From where the floodwall crosses 63rd Street to Hoak Drive, the area consists of mown lawn and planted trees and shrubs around a commercial building.

The project area provides little habitat for wildlife. Lack of cover limits the extended use of the site to such species as mice, shrews, and voles. The adjacent Walnut Creek corridor provides cover for other species such as the cottontail rabbit, opossum, raccoon, and various songbirds. These species may also use the construction area as temporary feeding sites or travel corridors.

The revised alignment has been disturbed by construction associated with 63rd Street and contains no known significant historic properties.

V. ENVIRONMENTAL IMPACTS OF THE PREFERRED ACTION.

The affects of the preferred plan are summarized on Table H-1.

1. Natural Resources. The proposed floodwall realignment would have similar impacts as the old floodwall plan. Construction would cause the loss of a grass groundcover and possibly a few landscaped trees and shrubs. Upon completion, however, the affected areas would be restored.

Most wildlife use the project area for temporary foraging or as an occasional travel way. Disturbance during construction may cause local animal populations to temporarily use other areas. The realignment of the floodwall to the east side of 63rd Street may provide a beneficial service by acting as a barrier and keeping local wildlife from the Walnut Creek area off the highway.

The nature of the project site is that of a heavily disturbed, urban area. Wildlife use is limited by the lack of cover and human disturbance. No unique or sensitive sites are present and the project would not cause any significant impacts.

2. Endangered Species. There are three federally listed threatened or endangered species reported for Polk County, Iowa. These are the bald eagle (Haliaeetus leucocephalus), the least tern (Sterna antillarum), and the piping plover (Charadrius melodus).

The bald eagle is listed as wintering in Polk County. It uses trees near large streams with open water as day time resting or feeding perches. At night or during harsh weather, the eagle may use large trees in sheltered valleys. Neither suitable day nor night habitat occurs within the project area, therefore no impacts to the bald eagle would occur.

The least tern and piping plover uses open sandbars or beaches for nesting or summer habitat, particularly alonglarger rivers and streams. No suitable habitat occurs within the project site or adjacent Walnut Creek and no impacts to either the least tern or piping plover would occur.

The final Supplement No. 1 to the final EIS found there to be no state listed threatened or endangered species known to occur within the immediate project vicinity. The disturbed nature of the area of the proposed realignment make it unlikely that any such species could occur at that site. Therefore impacts are not anticipated to occur to any state listed species.

3. Water Quality. Minor increases in turbidity may occur as a result of rainfall during construction. However, the site would be reseeded after completion of the floodwall and such increases would be temporary. No construction would occur in (nor fill be placed into) any wetlands or water.

4. Air Quality. There would be minor temporary increases in dust particles and in exhaust from machinery during construction. These would cease upon project completion.

5. Cultural Resources. A walkover survey of the revised alignment determined the entire area has been previously disturbed and has no potential to contain significant historic properties.

6. Manmade Resources. The realignment would affect no manmade resources.

TABLE H-1

Effects of the Preferred Plan on Natural and Cultural Resources

Types of Resources	Authorities	Measurement of Effects
Air Quality	Clean Air Act, as amended (42 U.S.C. 165h-7, et seq.)	Minor, temporary effect.
Areas of particular concern with the coastal zone	Coastal Zone Management Act of 1972, as amended (16 U.S.C. 1451, et seq.)	Not present in planning area
Endangered and threatened species critical habitat	Endangered Species Act of 1973, as amended (16 U.S.C. 1531, et seq.)	No effect
Fish and wildlife habitat	Fish and Wildlife Coord'nation Act (16 U.S.C. 661, et seq.)	No significant effect.
Floodplains	Executive Order 11988, Flood Plain Management	No significant effect.
Historic and cultural properties	National Historic Preservation Act of 1966, as amended (16 U.S.C. 470, et seq.)	No effect.
Prime and unique farmland	CEQ Memorandum of August 1, 1980; Analysis of Impacts on Prime or Unique Agricultural Land in Implementing the National Environmental Policy Act	No effect.
Water quality	Clean Water Act of 1977, as amended (33 U.S.C. 1251, et seq.)	Minor, temporary effect.
Wetland	Executive Order 11990, Protection of Wetlands, Clean Water Act of 1977, as amended (42 U.S.C. 1857h-7, et seq.)	No effect.
Wild and scenic rivers	Wild and Scenic Rivers Act, as amended (16 U.S.C. 1271, et seq.)	Not present in planning area.

7. Farm Displacement. The project site is in an intensively urbanized area. No farms or land normally farmed would be displaced.

8. Noise Levels. The project plans would cause a temporary increase in noise levels as a result of construction. The levels would essentially be the same as with the previous floodwall alignment. Movement of the floodwall to the east side of 63rd Street would have a beneficial effect in that it would move construction farther away f m existing businesses. All increases would be minor, however, and end upon project completion.

9. Aesthetics. Floodwall construction would take place in an area already intensively developed with manmade structures and should not significantly affect the aesthetics of the area. The landscaping plan (for the entire project) is designed to soften aesthetic impacts. Floodwall realignment from the west to the east side of 63rd Street would cause little if any changes in aesthetic impacts.

10. Community and Regional Growth. The project would not significantly impact community or regional growth. Impacts to the immediate project area would be more pronounced than impacts to the region as a whole.

11. Displacement of People. The overall project would necessitate the removal of one residential structure. Given the availability of comparable housing within the project vicinity, the relative impact of this relocation would not be significant. The realignment to the west side of 63rd Street would cause no additional relocations.

12. Community Cohesion. The project would solidify and improve community cohesion by reducing the impacts of flooding. Flood waters acting as a barrier separating portions of the community would be reduced, allowing for uninterrupted interaction between residents and uninterrupted business activity.

13. Property Values and Tax Revenues. Property values might increase following construction of the proposed flood control project. Related tax revenues could be positively affected by any change in property values.

14. Public Facilities and Resources. Services to and from affected properties would improve as a result of project. An unquantified benefit would be uninterrupted emergency services; during times of flooding, emergency vehicles must drive at reduced speeds, slowing response times. Additional benefits would accrue from reduced damages to schools, parks, the city water works, city hall, and police station.

15. Life, Health, and Safety. The provision of flood protection would reduce life, health, and safety risks faced by West Des Moines and Des Moines residents affected by Walnut Creek and Raccoon River flooding. In particular, the project would help eliminate the health and other risks associated with standing water in structures. The realignment would cause no changes to the overall flood protection.

16. Employment and Labor Force. The project would not significantly affect the permanent employment or labor force of the cities of Des Moines or West Des Moines, Iowa. Although, the project as a whole may temporarily

increase area employment during the construction phase, the realignment would cause essentially no change.

17. Business and Industrial Development. The project would temporarily increase business and industrial activity during project construction. The overall project would necessitate the relocation of two business properties. No additional relocations would be required by the realignment.

VI. ENVIRONMENTAL IMPACTS OF NONPREFERRED ALTERNATIVES.

With the no action alternative, no construction would take place. Subsequently, there would be no project related impacts.

With floodwall placement on the west side of 63rd Street (no change), construction would affect similar habitat as the proposed realignment and environmental impacts would be essentially the same.

VII. PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED.

Exhaust and dust from construction and the loss of mainly groundcover within the floodwall alignment cannot be avoided.

VIII. ANY IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IF THE PROPOSED ACTION SHOULD BE IMPLEMENTED.

The purchase of materials and the commitment of man-hours, fuel, and machinery to perform the project are irretrievable.

IX. RELATIONSHIP OF THE PROJECT TO LAND-USE PLANS.

The project area is zoned for various urban uses such as residential or business-commercial. The purpose of this project is to enhance such uses by providing flood protection and is therefore compatible with the existing zoning.

X. COMPLIANCE WITH ENVIRONMENTAL QUALITY STATUTES.

A summary of compliance can be found in Table H-2.

1. Endangered Species. No threatened or endangered species would be affected by the proposed project. The U.S. Fish and Wildlife Service (FWS) during coordination has concurred with this.

2. Cultural Resources. No historic or cultural resources would be affected by the project. Coordination with the SHPO has concurred with this.

TABLE H-2

Compliance of the Preferred Plan with WRC-Designated Environmental Statutes

Federal Policies	Compliance
Archaeological and Historic Preservation Act, 16 U.S.C. 469, et seq.	Full compliance
Clean Air Act, as amended, 42 U.S.C. 165h-7 et seq.	Full compliance
Clean Water Act (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq.	Full compliance
Coastal Zone Management Act, 16 U.S.C. 1451, et seq.	Not Applicable
Endangered Species Act, 16 U.S.C. 1531, et seq.	Full compliance
Estuary Protection Act, 16 U.S.C. 1221, et seq.	Not Applicable
Federal Water Project Recreation Act, 16 U.S.C. 460-1(12), et seq.	Full compliance
Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq.	Full compliance
Land and Water Conservation Fund Act, 16 U.S.C. 4601, et seq.	Full compliance
Marine Protection Research and Sanctuary Act 33 U.S.C. 1401, et seq.	Not Applicable
National Environmental Policy Act, 42 U.S.C. 4321, et seq.	Full compliance
National Historic Preservation Act, 16 U.S.C. 470a, et seq.	Full compliance
Rivers and Harbors Act, 33 U.S.C. 401, et seq.	Full compliance
Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.	Full compliance
Wild and Scenic Rivers Act, 16 U.S.C. 1271, et seq.	Not Applicable

3. Federal Water Project Recreation Act. The realignment would not alter the recreational opportunities of the project. Included in the overall project design are a 2.8 mile bike path with on/off ramps and road and railroad crossings; and a one lane boat ramp with parking lot.

4. Fish and Wildlife Coordination Act. No significant impacts to fish or wildlife would occur as a result of the realignment. Both the Iowa Department of Natural Resources (IDNR) and the FWS have indicated no objections to the project.

5. Executive Order 11998, Flood Plain Management. The proposed project would take place within a developed urban area.

6. Wild and Scenic Rivers. No wild or scenic rivers or rivers proposed for study or currently under study for inclusion as a wild or scenic river are within the project area.

7. Executive Order 11990, Protection of Wetlands. No fill would be placed in any wetlands or waters.

8. Clean Water Act. Minor increases in turbidity as a result of construction may occur during periods of rapid rainfall runoff. These increases would be temporary with no anticipated violations to water quality standards.

9. Clean Air Act. Minor, temporary impacts to air quality would occur from increased dust and exhaust during construction. No air quality standards should be violated.

10. Farmland Protection Policy Act. The project would be located in an intensive urban area. No farmlands would be affected.

XI. COORDINATION.

The proposed realignment has been coordinated with the U.S. Fish and Wildlife Service(FWS), Iowa Department of Natural Resources(IDNR), U.S. Environmental Protection Agency(U.S. EPA), and the Iowa State Historic Preservation Officer(SHPO). Copies of the comments received can be found under "Pertinent Correspondence".

The FWS, IDNR, and SHPO expressed no objection to the project. The U.S. EPA expressed concern that the floodwall is located riverward of the floodway boundary and could cause flood elevation impacts caused by narrowing of the floodway. It was suggested that depressions could be located riverward of the flood wall to provide areas for water retention to promote the establishment of wetland areas. A review of the hydraulics of the stream and the physical nature of the narrow floodway indicate that the creation of depressions are not feasible. As listed under the project description, the two bridges on Grand Avenue and 63rd Street will have their openings cleaned out to offset encroachment into the floodway.

FINDING OF NO SIGNIFICANT IMPACT

Having reviewed the information contained in this environmental assessment, I find the realignment of 1854 feet of floodwall in the Walnut Creek and Raccoon River, West Des Moines-Des Moines Flood Control Project will have no significant effects on the quality of the human environment. Therefore the preparation of an Environmental Impact Statement (EIS) is not required. This determination will be reevaluated if warranted by later developments. Factors that were considered in making this determination were:

1. The realignment would lessen construction impacts and visual obstructions to local businesses as well as better accommodating any future highway improvements to 63rd Street and Grand Avenue.

2. Environmental impacts would remain essentially unchanged from the old alignment to the new realignment.

3. The construction of the realigned floodwall should cause no significant environmental, cultural, social, or economic impacts.

_____
Date

John R. Brown
Colonel, U.S. Army
District Engineer

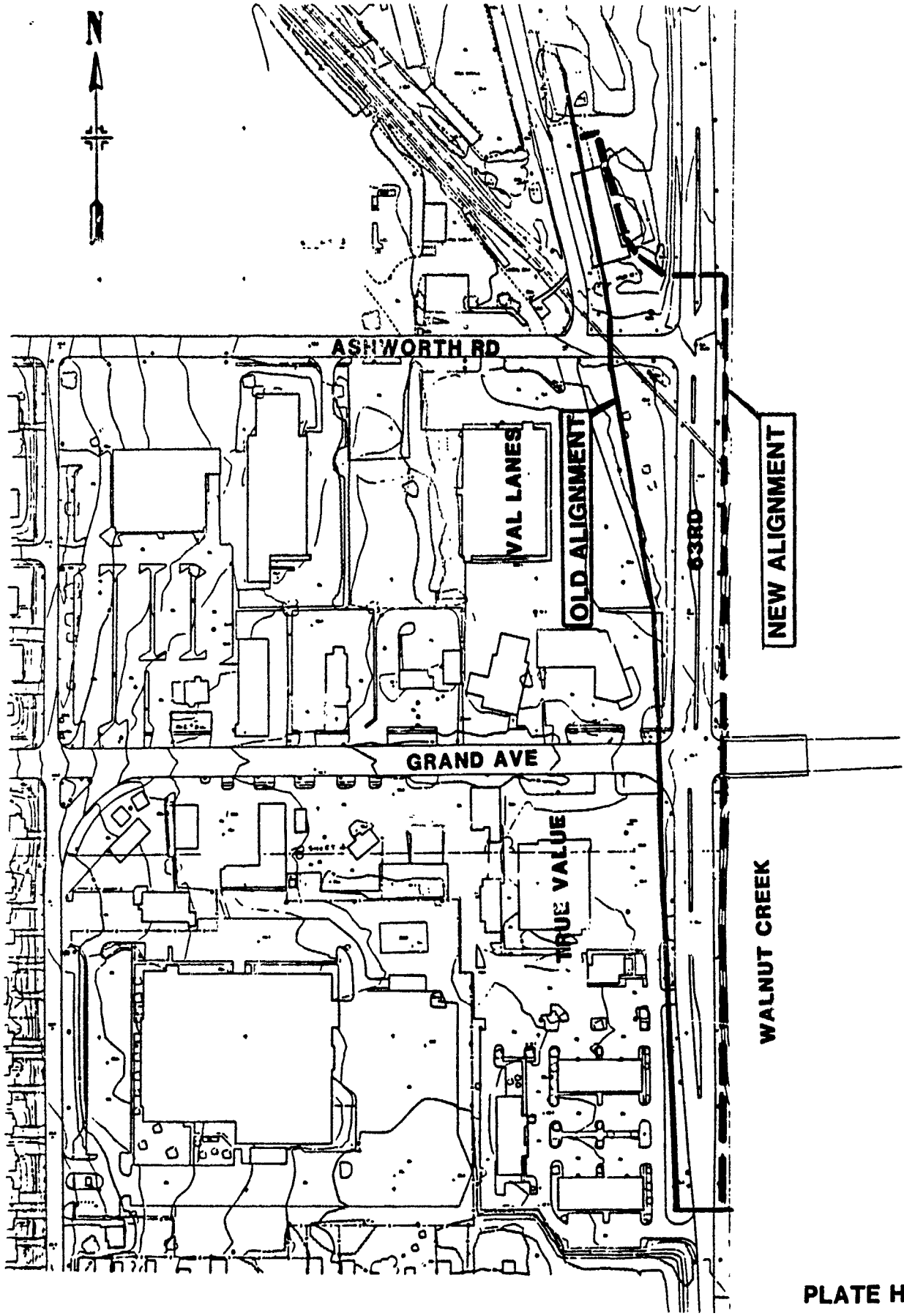

N
ASHWORTH RD
VAL LANES
OLD ALIGNMENT
63RD
NEW ALIGNMENT
GRAND AVE
TRUE VALUE
WALNUT CREEK

PLATE H-1

PERTINENT CORRESPONDENCE

State Historical Society of Iowa

The Historical Division of the Department of Cultural Affairs

June 20, 1990

In reply refer to:
RC# 881077080

Mr. Dudley M. Hanson, P.E.
Chief, Planning Division
Rock Island District Corps of Engineers
Clock Tower Building
P.O. Box 2004
Rock Island, IL 61204-2004

RE: COE - DACW25-88-M-1166 - POLK COUNTY - WEST DES MOINES - FLOOD CONTROL PROJECT FOR RACCOON RIVER AND WALNUT CREEK - REALIGNED FLOODWALL

Dear Mr. Hanson:

Based on the information you provided, we find that there are no historic properties which might be affected by the proposed undertaking. Therefore, we recommend project approval.

However, if the proposed project work uncovers an item or items which might be of archeological, historical or architectural interest, or if important new archeological, historical or architectural data come to light in the project area, you should make reasonable efforts to avoid or minimize harm to the property until the significance of the discovery can be determined.

Should you have any questions or if the office can be of further assistance to you, please contact the Review & Compliance program at 515-281-8743.

Sincerely,

Kay Simpson
Archeologist, Review and Compliance Program
Bureau of Historic Preservation

/mtm

☐ 402 Iowa Avenue
Iowa City, Iowa 52240
(319) 335-3916

☐ Capitol Complex
Des Moines, Iowa 50319
(515) 281-5111

☐ Montauk
Box 372
Clermont, Iowa 52135
(319) 423-7773

CONVERSATION RECORD	TIME: 0900	DATE: 30 May 1990

TYPE ( )VISIT ( )CONFERENCE (x)TELEPHONE (x)INCOMING ( )OUTGOING

ROUTING

NAME	INT

NAME CONTACTED	ORGANIZATION	TELEPHONE
Chuck Davis	U.S. Fish and Wildlife	(309)793-5800

SUBJECT:
Raccoon River and Walnut Creek
West Des Moines - Des Moines, Iowa

SUMMARY: Chuck Davis called in regards to the project. He said that in regards to Fish and Wildlife concerns and Threatened and Endangered Species concerns, his office had no objections to the proposal to move the floodwall from the west side to the east side of 63rd Street. I said I would write up a telecom to serve as coordination with his agency. He said that would be fine.

ACTION REQUIRED
NONE

NAME OF PERSON DOCUMENTING CONVERSATION:	SIGNATURE	DATE
Ron Klump	Ron Klump	1 June 1990

ACTION TAKEN

SIGNATURE	TITLE	DATE

50271-101 CONVERSATION RECORD (12-76)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VII
726 MINNESOTA AVENUE
KANSAS CITY, KANSAS 66101

May 11, 1990

Colonel John R. Brown, USA
District Engineer
U.S. Army Engineer District, Rock Island
ATTN: Planning Division
Clock Tower Building
P.O. Box 2004
Rock Island, Illinois 61204-2004

Dear Colonel Brown:

RE: Coordination on Proposed Change to the Flood Control Project for the Racoon River and Walnut Creek in West Des Moines and Des Moines, Iowa

Thank you for your letter dated April 16, 1990. We have reviewed your proposed changes and look forward to receiving the Environmental Assessment when it is prepared. We are concerned that the flood wall is located riverward of the floodway boundary. We assume the EA will contain projected flood elevation impacts caused by the narrowing of the floodway. Perhaps depressions could be located riverward of the flood wall to provide areas for water retention to promote the establishment of wetland areas.

If you have any questions, please write to me or call Mr. Dewayne Knott at (913) 551-7299. Thank you for the opportunity to coordinate with you on this project.

Sincerely,

Lawrence M. Cavin
Chief, Environmental Review
and Coordination Section

CONVERSATION RECORD	TIME: 1300	DATE: 9 May 1990

TYPE ( )VISIT ( )CONFERENCE (x)TELEPHONE (xINCOMING ( )OUTGOING

ROUTING

NAME	INT

NAME CONTACTED	ORGANIZATION	TELEPHONE
Kathleen Lee	IDNR Water Quality Div.	( ) -

SUBJECT: Racoon River and Walnut Creek, West Des Moines - Des Moines, IA

SUMMARY:

Kathleen Lee stated her office had reviewed the proposed changes to the above listed project. She explained that her office had no objections or comments to moving the floodwall to the east side of 63rd Street and no letter would be forthcoming. I stated I would write up a conversation record of our conversation. She said that would be fine.

ACTION REQUIRED

NAME OF PERSON DOCUMENTING CONVERSATION:	SIGNATURE	DATE
Ron Klump	Ron Klump	9 May 1990

ACTION TAKEN

SIGNATURE	TITLE	DATE

APPENDIX I

PERTINENT CORRESPONDENCE

February 14, 1990

Engineering Division
Project Management Section

SUBJECT: West Des Moines - Des Moines Local Flood Protection Project, Raccoon River and Walnut Creek

Mr. L. P. Vanderleest
Manager of Engineering Services
Chicago and North Western
Transportation Company
One North Western Center
Chicago, Illinois 60606

Dear Mr. Vanderleest:

We are in the process of completing a General Design Memorandum for the subject project. The project will provide flood protection for a portion of the cities of Des Moines and West Des Moines, Iowa. The project consists of a series of earthen levees and floodwalls. The line of protection will crosse your company's tracks at Railroad Avenue and 61st Street in Des Moines, Iowa. There is currently a main line track and side track at this location.

We have discussed our plans by telephone with Mr. Mark Briley of your Des Moines office. We are currently planning a double gated closure structure at this location. Preliminary drawings are included with this letter. The gates would be five feet high with an opening of forty feet. The gates would be closed when a flood with a frequency of once in forty years is threatening to flood the cities. This represents a flood with a 2.5 percent chance of happening in any given year.

Construction would be accomplished by working on one track at a time. This would allow through traffic to be maintained at all times. A government contractor would perform the majority of the work. We would appreciate it if you would review our proposed plans and comment on them. We would like to incorporate any comments that you may have into our General Design Memorandum. This report will be finalized in April of 1990.

If you have any questions regarding our proposed improvements in the Des Moines, Iowa area, please contact Mr. Keith Haas at (309) 788-6361, ext. 507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

Copies Furnished (w/enclosures):

Mr. Mike Klapp
Principal Civil Engineer
City Hall
East First and Locust
Des Moines, Iowa 50307

Mr. Mark Briley
Roadmaster
Chicago North Western
Transportation Company
2730 Southeast Market Street
Des Moines, Iowa 50317

CF:
ED-D (Dist File)
ED-DM
RE-A

Mr. Haas/sh/6507

April 4, 1990

Project Management Section
Design Branch

SUBJECT: Raccoon River and Walnut Creek, West Des Moines - Des Moines, Iowa, Local Flood Protection Project

Mr. Jack Riessen, P.E.
Flood Plain Permits Section
Department of Natural Resources
Wallace State Office Building
East 9th Street and Grand Avenue
Des Moines, Iowa 50319

Dear Mr. Riessen:

We are in the process of refining the engineering aspects of the subject project. A General Reevaluation Report (GRR) was prepared by our office and completed in July 1989. The plan included a system of earthen levees, concrete floodwalls, and steel gates. The planned GRR alignment follows the Flood Insurance Study mapped floodway in the area north of Grand Avenue in West Des Moines, Iowa. The floodway is mapped on the west side of 63rd Street in this area. In order to accommodate future plans of the Iowa Department of Transportation, reduce impacts to local businesses in the area, and improve overall project operation, we have moved the proposed floodwall to the east side of 63rd Street from just south of Grand Avenue to just north of Ashworth Road. A floodwall has also been proposed to protect the Midland Brick Company and will tie into a levee section on Hoak Drive past the entrances of the Beisser and Wheeler lumber companies.

This refinement causes a slight encroachment into the mapped floodway. In order to mitigate this encroachment we are proposing bridge cleanouts at Grand Avenue and at 63rd Street and Walnut Creek. Mathematical hydraulic computations have been performed utlizing the backwater program HEC-2. These results were presented to you by our Messrs. Roger Less and Keith Haas on February 21, 1990 in Des Moines. We are seeking the approval of your office in making this change in the mapped floodway. We have enclosed a drawing depicting the proposed refinement. Our hydraulic computations can also be provided to you if you would care to review them.

We are preparing a Design Memorandum (DM) for the project that is scheduled to be completed in June of 1990. We would appreciate a response from your office that can be included

in this DM. If you have any questions regarding our planned improvements, please contact Mr. Keith Haas at (309) 788-6361, extension 507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

CF:
ED-D (Dist File)
ED-HH
ED-DM
DP

STATE OF IOWA

TERRY E. BRANSTAD, GOVERNOR

DEPARTMENT OF NATURAL RESOURCES
LARRY J. WILSON, DIRECTOR

April 17, 1990

Robert W. Kelly, P.E.
Chief, Engineering Division
Rock Island District, Corps of Engineers
Clock Tower Bldg., P.O. Box 2004
Rock Island, IL 61202-2004

Dear Mr. Kelly:

This letter is in repsonse to your letter of April 4, 1990 in which you discussed the proposed realignment of the Walnut Creek floodwall in the vicinity of 63rd and Grand. According to the information presented, the floodwall would be relocated streamward to the east side of 63rd Street, which would be an encroachment on the Walnut Creek floodway. To mitigate any increase in flood levels that this would cause, bridge cleanouts are being proposed at the Grand Avenue and the 63rd Street bridges.

We have no objection to the proposed relocation providing the mitigation measures (i.e., the bridge cleanouts) are implemented and properly maintained. Therefore, it is essential that the Design Memorandum or other appropriate document clearly identify the procedure for insuring that the bridge openings are maintained. The procedure should address the responsiblity and frequency of maintenance (or inspections to determine maintenance needs) as well as the the design cross section geometry.

Thank you for the opportunity to comment. If you should have any questions, feel free to contact me.

Sincerely,

Jack D. Riessen, P.E.
Supervisor
Floodplain Management Section

WALLACE STATE OFFICE BUILDING / DES MOINES, IOWA 50319 / 515 281 5145/ TDD 515 242 5967 / FAX 515 281 8895

CHESAPEAKE
DISPLAY & PACKAGING
COMPANY

June 19, 1990

Mr. Robert W. Kelly, P.E.
Department of the Army
Rock Island District, Corps of Engineers
Clock Tower Building
P.O. Box 2004
Rock Island, IL 61204-2004

Dear Mr. Kelly:

The recent flooding in West Des Moines reminded me that I had not responded to your letter regarding development of our land and capital improvements. We are developing plans to expand our facilities both to the east and to the south into the field we own. This expansion would allow us to increase our manufacturing space.

In addition to the building expansion, we would require rail service off the line that runs to our south. This is in the area of the levee you plan.

Please involve us in your discussions so we can assist in this flood control program while allowing us room to expand and remain in West Des Moines.

Sincerely,

Robert G. Larson
Vice President & General Manager

RL/dsd
cc: Ralph Spear

520 South 18th Street, West Des Moines, Iowa 50265, (515) 223-5560

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P O BOX 2004
ROCK ISLAND ILLINOIS 61204 2004

REPLY TO
ATTENTION OF

December 19, 1990

Design Branch
Civil Engineering Section

Mr. Brian Butler
Heritage Cable TV
2205 Ingersoll Avenue
Des Moines, Iowa 50312

Dear Mr. Butler:

We are currently completing a Design Memorandum for a flood control project in West Des Moines and Des Moines, Iowa along Walnut Creek and the Raccoon River. The project will involve the construction of earthen levees and concrete retaining walls in these cities. The construction of these structures will involve the relocation of cable lines both overhead and underground along the project limits.

We are furnishing you with two sets of a general plan and plan and profile drawings (Plates 4-22) showing the general location of project features. At this time we do not have any information regarding the location of cable lines in the project area. We would appreciate it if you would mark the location of your lines on one set of drawings and return them to us. A copy of the complete Design Memorandum will be furnished to you when available.

As part of the provisions of the Local Cooperation Agreement with the cities, they will be responsible for coordination and relocation of all affected utilities prior to construction. Any costs associated with utility work are non-federal items but contribute to the total project cost.

Please prepare an estimate of the costs associated with any relocation work required because of the project. We would appreciate a response by February 28, 1991. We are preparing plans and specifications for the northern part of the project beginning in March 1991. If you have any questions regarding the project, please call Mr. Keith Haas, at (309) 788-6361, extension 6507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

Copies Furnished:

Mr. Duane Wittstock
City Engineer
1514 Fuller Road
West Des Moines, IA 50265

Mr. Mike Klapp
City Engineer
City Hall
East First and Locust
Des Moines, IA 50307

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P O BOX 2004
ROCK ISLAND ILLINOIS 61204-2004

REPLY TO
ATTENTION OF

December 19, 1990

Design Branch
Civil Engineering Section

Mr. Randy Beavers
2201 Valley Drive
Des Moines, Iowa 50321

Dear Mr. Beavers:

We are currently completing a Design Memorandum for a flood control project in West Des Moines and Des Moines, Iowa along Walnut Creek and the Raccoon River. The project will involve the construction of earthen levees and concrete retaining walls in these cities. The construction of these structures will involve the relocation of water lines and installing valves on existing lines along the project limits.

We are furnishing you with a general plan and plan and profile drawings (Plates 4-22) showing the general location of water lines, together with a utility schedule which shows the disposition of all water lines known to be affected by the project. A copy of the Design Memorandum will be furnished to you when available.

As part of the provisions of the Local Cooperation Agreement with the cities, they will be responsible for coordination and relocation of all affected utilities prior to construction. Any costs associated with utility work are non-federal items but contribute to the total project cost.

We would appreciate it if you would review our drawings and provide us with any comments regarding revisions or omissions that may exist. We would appreciate a response by February 28, 1991. We will be preparing plans and specifications for the northern part of the project beginning March 1991. If you have any questions regarding the project, please call Mr. Keith Haas, at (309) 788-6361, extension 6507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

Copies Furnished:

Mr. Duane Wittstock
City Engineer
1514 Fuller Road
West Des Moines, IA 50265

Mr. Mike Klapp
City Engineer
City Hall
East First and Locust
Des Moines, IA 50307

DES MOINES WATER WORKS

2201 Valley Drive
Des Moines, Iowa 50321-1190
(515) 283-8755

BOARD OF WATER WORKS TRUSTEES
L.D. McMULLEN, Ph.D., P.E., SECRETARY AND GENERAL MANAGER

January 14, 1991

Mr. Robert W. Kelly
Chief of Engineering Division
U.S. Army Corp of Engineers
Clock Tower Bldg.
P.O. Box 2004
Rock Island, IL 61204-2004

SUBJECT: Raccoon River Local Flood Protection -
West Des Moines, Iowa

Dear Mr. Kelly:

Des Moines Water Works has reviewed the plan and profile drawings for the above referenced project and it appears all of our facilities are shown correctly. Our only involvement will be in two locations where the proposed levee crosses a 24" feeder main east of S.W. 63rd Street.

In a discussion with Keith Haas, of your office, Mr. Haas suggested that, at this time, we send to you general information regarding the feeder main. This main was installed in 1974 and is constructed of 24" ductile iron pipe. There are two valves on this main on the land side of the proposed levee, one at Gordon Street and one just south of Railroad Avenue. Our records show that there have been no breaks on this main north of the Raccoon River since installation.

At levee Sta. 90+70, the feeder main crosses at a 90° angle as shown on your Plate 11. At this point, our main is between 10' and 12' deep. At levee Sta. 177+22, the proposed construction once again crosses perpendicular to our main as shown on your Plate 18. At this point, there is approximately 3' of cover over the main and all joints are harnessed for 80' west of the levee and 200' east of the levee.

Enclosed are reduced copies of our quarter section maps showing the area in question. The feeder main is highlighted in green and the location of the levee is shown in yellow. These maps can be used to identify which valves would need to be closed in the event of a break. Please note that any valves in the flood plain would

be inaccessible during flooding. Also note that this is a looped system with flow coming from both directions. All valves leading into a break area must be closed to stop the flow.

If you have any questions or if you need further information, please contact me.

Sincerely,

Ted Corrigan, P.E.
Engineer
(515)283-8725

TC/clk

Attachment

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P O BOX 2004
ROCK ISLAND ILLINOIS 61204-2004

REPLY TO ATTENTION OF

December 19, 1990

Design Branch
Civil Engineering Section

Mr. Ed Stangle
City of West Des Moines
1514 Fuller Road
West Des Moines, Iowa 50265

Dear Mr. Stangle:

We are currently completing a Design Memorandum for a flood control project in West Des Moines and Des Moines, Iowa along Walnut Creek and the Raccoon River. The project will involve the construction of earthen levees and concrete retaining walls in these cities. The construction of these structures will involve the relocation of sanitary and storm sewers along the project limits.

We are furnishing you with a general plan and plan and profile drawings (Plates 4-22) showing the general location of sewer lines, together with a gatewell schedule which shows the disposition of all sewer lines known to be affected by the project. A copy of the Design Memorandum will be furnished to you when available.

We would appreciate it if you would review our drawings and provide us with any comments regarding revisions or omissions that may exist. We would appreciate a response by February 28, 1991. We will be preparing plans and specifications for the northern part of the project beginning in March 1991. If you have any questions regarding the project, please call Mr. Keith Haas, at (309) 788-6361, extension 6507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

Copies Furnished:

Mr. Duane Wittstock
City Engineer
1514 Fuller Road
West Des Moines, IA 50265

Mr. Mike Klapp
City Engineer
City Hall
East First and Locust
Des Moines, IA 50307

CITY OF WEST DES MOINES

DEPARTMENT OF PUBLIC WORKS

February 26, 1991

Mr. Keith Haas
U.S. Army Corps of Engineers
Rock Island District
Clock Tower Building
Rock Island, IL 61204-2004

Re: West Des Moines Flood Control Project

Dear Keith:

Enclosed are the copies of Plates 4 and 5 from the Draft Design Memorandum that we were sent for review of existing sewer locations.

Our records show a minor difference in the location of the sanitary sewers north of the railroad on Plate 4. The locations from our records have been marked in red. On Plate 4 and 5, we have installed a 10 inch PVC sewer force main south of the railroad and parallel to it. This has also been marked in red on the drawings. Also, on Plate 5, the building labelled as "Chesapeake Display and Packing Co." is the West Des Moines Public Works.

Please contact us if you have any questions or comments.

Sincerely,

Edward W. Stangl, P.E.
Environmental Engineer

EWS/nl

Enclosure

450-009

1514 FULLER ROAD ■ WEST DES MOINES IOWA 50265 ■ ENGINEERING DIVISION 515/223 3261 ■ OPERATIONS DIVISION 515/223 3231

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P O BOX 2004
ROCK ISLAND ILLINOIS 61204-2004

REPLY TO
ATTENTION OF

December 21, 1990

Design Branch
Civil Engineering Section

Mr. Bill Young, Engineer
U.S. Sprint Communications Company
Des Moines, Iowa 50309

Dear Mr. Young:

We are currently completing a Design Memorandum for a flood control project in West Des Moines and Des Moines, Iowa along Walnut Creek and the Raccoon River. This project will involve the construction of earthen levees and concrete retaining walls in these cities. These structures are known to cross a transcontinental fiber optics cable at two locations.

We are furnishing you with a general plan and the plan and profile drawings (plates 4-22) showing the general location of telephone lines, together with a Utility Schedule which shows the disposition of all telephone lines known to be affected by the project. A copy of the complete Design Memorandum will be furnished to you when it becomes available.

As part of the provisions of the Local Cooperation Agreement with the cities, they will be responsible for coordination of all utilities affected by the project prior to construction. Any costs associated with utility work are non-federal items but contribute to the total project cost.

We would appreciate it if you would review our drawings and provide us with any comments regarding revisions or omissions that may exist. We would appreciate a response by

February 28, 1991. We will be preparing plans and specifications for the northern part of the project beginning in March 1991. If you have any questions regarding the project, please call Mr. Keith Haas at (309) 788-6361, extension 6507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

Copy Furnished:

Mr. Duane Wittstock
City Engineer
1514 Fuller Road
West Des Moines, IA 50265

Mr. Mike Klapp
City Engineer
City Hall
East First and Locust
Des Moines, IA 50307

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P O BOX 2004
ROCK ISLAND ILLINOIS 61204 2004

REPLY TO
ATTENTION OF

December 19, 1990

Design Branch
Civil Engineering Section

Mr. Larry R. Anderson
West Des Moines Waterworks
P.O. Box 65610
West Des Moines, Iowa 50265

Dear Mr. Anderson:

We are currently completing a Design Memorandum for a flood control project in West Des Moines and Des Moines, Iowa along Walnut Creek and the Raccoon River. The project will involve the construction of earthen levees and concrete retaining walls in these cities. The construction of these structures will involve the relocation of water lines along the project limits.

We are furnishing you with a general plan and plan and profile drawings (Plates 4-22) showing the general location of water lines, together with a utility schedule which shows the disposition of all water lines known to be affected by the project. A copy of the Design Memorandum will be furnished to you when available.

As part of the provisions of the Local Cooperation Agreement with the cities, they will be responsible for coordination and relocation of all affected utilities prior to construction. Any costs associated with utility work are non-federal items but contribute to the total project cost.

We would appreciate it if you would review our drawings and provide us with any comments regarding revisions or omissions that may exist. We would appreciate a response by

February 28, 1991. We will be preparing plans and specifications for the northern part of the project beginning in March 1991. If you have any questions regarding the project, please call Mr. Keith Haas, at (309) 788-6361, extension 6507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

Copies Furnished:

Mr. Duane Wittstock
City Engineer
1514 Fuller Road
West Des Moines, IA 50265

Mr. Mike Klapp
City Engineer
City Hall
East First and Locust
Des Moines, IA 50307

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P O BOY 2004
ROCK ISLAND ILLINOIS 61204 2004

REPLY TO
ATTENTION OF

January 2, 1991

Design Branch
Civil Engineering Section

Ms. Joann Marshall
U.S. West Communications
2103 East University
Des Moines, Iowa 50317

Dear Ms. Marshall:

We are currently completing a Design Memorandum for a flood control project in West Des Moines and Des Moines, Iowa along Walnut Creek and the Raccoon River. This project will involve the construction of earthen levees and concrete retaining walls in these cities. These structures are known to cross a fiber optics cable at Grand Avenue near 63rd Street in Des Moines, Iowa.

We are furnishing you with a general plan and the plan and profile drawings (plates 4-22) showing the general location of telephone lines, together with a Utility Schedule which shows the disposition of all telephone lines known to be affected by the project. A copy of the complete Design Memorandum will be furnished to you when it becomes available.

As part of the provisions of the Local Cooperation Agreement with the cities, they will be responsible for coordination of all utilities affected by the project prior to construction. Any costs associated with utility work are non-federal items but contribute to the total project cost.

We would appreciate it if you would review our drawings and provide us with any comments regarding revisions or omissions

that may exist. We would appreciate a response by February 28, 1991. We will be preparing plans and specifications for the northern part of the project beginning in March 1991. If you have any questions regarding the project, please call Mr. Keith Haas at (309) 788-6361, extension 6507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

Copies Furnished:

Mr. Duane Wittstock
City Engineer
1514 Fuller Road
West Des Moines, IA 50265

Mr. Mike Klapp
City Engineer
City Hall
East First and Locust
Des Moines, IA 50307

U S WEST
COMMUNICATIONS

2103 E. University
Des Moines, Iowa 50317
March 19, 1991

Robert W. Kelley, P.E.
Chief Engineering Division
Department of the Army
Rock Island District Corps of Engineers
Clock Tower Building - P.O. Box 2004
Rock Island, Illinois
61204-2004

Dear Mr. Kelley:

RE: FLOOD CONTROL PROJECT - EARTHEN LEVEES AND RETAINING WALLS

I recently met with the City of West Des Moines Engineering Office to discuss the Design Memorandum for a flood control project in West Des Moines, Iowa.

According to their information, Stage I (January, 1993) involves Plates 20-22 Ashworth Road north on Hoak Drive. U S WEST has existing buried telephone facilities on the west portion of Hoak Drive going to Wheeler Lumber and existing business in the area.

Stage II
Plates 4-11 (January, 1994)
U S WEST has existing buried facilities on Plates 5-7 & 9.

Stage III
Plates 12-19 (May, 1994)
The fiber cable shown on Plate 12 belongs to AT&T and not U S WEST. Plate 18 shows existing U S WEST conduit (Telephone Manhole) and buried cable crossing SW 63rd Street that will be involved in your construction. You will need to contact Mary Andersen, (515-263-7223), the engineer involved in that area. Plate 19 is minus conduit and a manhole crossing from the intersection of Grand Avenue and SW 63rd Street northwest through the Val Lanes parking lot to Ashworth Road. The existing manhole is in their parking lot.

Thank you for asking for U S WEST input and Mary and I will be happy to work with you. Please contact One Call 1-800-292-8989 before starting work.

Sincerely,

Joann K. Marshall

Joann K. Marshall
Manager-Engineering

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT CORPS OF ENGINEERS
CLOCK TOWER BUILDING - P O BOX 2004
ROCK ISLAND ILLINOIS 61204 2004

REPLY TO ATTENTION OF

December 21, 1990

Design Branch
Civil Engineering Section

Mr. Charles A. Wellman
Gas Engineer
Midwest Gas Company
200 Southeast 3rd
P.O. Box 10410
Des Moines, Iowa 50306

Dear Mr. Wellman:

We are currently completing a Design Memorandum for a flood control project in West Des Moines and Des Moines, Iowa along Walnut Creek and the Raccoon River. The project will involve the construction of earthen levees and concrete retaining walls in these cities. The construction of these structures will involve the relocation of gas lines and installation of some valves along the project limits.

We are furnishing you with a general plan and plan and profile drawings (Plates 4-22) showing the general location of gas lines, together with a utility schedule which shows the disposition of all gas lin known to be affected by the project. A copy of the Design Memora dum will be furnished to you when available.

As part of the provisions of the Local Cooperation Agreement with the cities, they will be responsible for coordination and relocation of all affected utilities prior to construction. Any costs associated with utility work are non-federal items but contribute to the total project cost.

We would appreciate it if you would review our drawings and provide us with any comments regarding revisions or omissions that may exist. We would appreciate a response by

February 28, 1991. We will be preparing plans and specifications for the northern part of the project in March 1991. If you have any questions regarding the project, please call Mr. Keith Haas, at (309) 788-6361, extension 6507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

Copies Furnished:

Mr. Duane Wittstock
City Engineer
1514 Fuller Road
West Des Moines, IA 50265

Mr. Mike Klapp
City Engineer
City Hall
East First and Locust
Des Moines, IA 50307

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P O BOX 2004
ROCK ISLAND ILLINOIS 61204 2004

REPLY TO
ATTENTION OF

December 19, 1990

Design Branch
Civil Engineering Section

Mr. Bill Spraque
Iowa Power Company
823 Walnut
Des Moines, Iowa 50303

Dear Mr. Spraque:

We are currently completing a Design Memorandum for a flood control project in West Des Moines and Des Moines, Iowa along Walnut Creek and the Raccoon River. The project will involve the construction of earthen levees and concrete retaining walls in these cities. The construction of these structures will involve the relocation of power lines both overhead and underground along the project limits.

We are furnishing you with a general plan and plan and profile drawings (Plates 4-22) showing the general location of power lines, together with a utility schedule which shows the disposition of all power lines known to be affected by the project. A copy of the Design Memorandum will be furnished to you when available.

As part of the provisions of the Local Cooperation Agreement with the cities, they will be responsible for coordination and relocation of all affected utilities prior to construction. Any costs associated with utility work are non-federal items but contribute to the total project cost.

We would appreciate it if you would review our drawings and provide us with any comments regarding revisions or omissions that may exist. We would appreciate a response by

February 28, 1991. We will be preparing plans and specifications for the northern part of the project beginning in March 1991. If you have any questions regarding the project, please call Mr. Keith Haas, at (309) 788-6361, extension 6507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

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Mr. Duane Wittstock
City Engineer
1514 Fuller Road
West Des Moines, IA 50265

Mr. Mike Klapp
City Engineer
City Hall
East First and Locust
Des Moines, IA 50307

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P O BOX 2004
ROCK ISLAND ILLINOIS 61204-2004

REPLY TO
ATTENTION OF

January 8, 1991

Design Branch
Civil Engineering Section

Mr. Larry Schneidmiller, Engineer
U.S. Sprint Communications Company
2721 West Oxford, Suite 5
Englewood, Colorado 80110

Dear Mr. Schneidmiller:

We are currently completing a Design Memorandum for a flocd control project in West Des Moines and Des Moines, Iowa along Walnut Creek and the Raccoon River. This project will involve the construction of earthen levees and concrete retaining walls in these cities. These structures are known to cross a transcontinental fiber optics cable at two locations.

We are furnishing you with a general plan and the plan and profile drawings (plates 4-22) showing the general location of telephone lines, together with a Utility Schedule which shows the disposition of all telephone lines known to be affected by the project. A copy of the complete Design Memorandum will be furnished to you when it becomes available.

As part of the provisions of the Local Cooperation Agreement with the cities, they will be responsible for coordination of all utilities affected by the project prior to construction. Any costs associated with utility work are non-federal items but contribute to the total project cost.

We would appreciate it if you would review our drawings and provide us with any comments regarding revisions or omissions that may exist. We would appreciate a response by

February 28, 1991. We will be preparing plans and specifications for the northern part of the project beginning in March 1991. If you have any questions regarding the project, please call Mr. Keith Haas at (309) 788-6361, extension 6507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

Copy Furnished:

Mr. Duane Wittstock
City Engineer
1514 Fuller Road
West Des Moines, IA 50265

Mr. Mike Klapp
City Engineer
City Hall
East First and Locust
Des Moines, IA 50307

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT CORPS OF ENGINEERS
CLOCK TOWER BUILDING - P O BOX 2004
ROCK ISLAND, ILLINOIS 61204 2004

REPLY TO
ATTENTION OF

January 9, 1991

Design Branch
Civil Engineering Section

SUBJECT: West Des Moines - Des Moines, Iowa, Local Flood Protection Project

Mr. G. E. Drake, Chief Engineer
Design and Construction
Norfolk Southern Corporation
99 Spring Street, S.W.
Atlanta, Georgia 30303

Dear Mr. Drake:

We are currently completing a Design Memorandum for the West Des Moines - Des Moines, Iowa, Local Flood Protection project. We will be preparing plans and specifications for this project later this year. This flood control project will cross the Norfolk Southern tracks at two locations in West Des Moines, Iowa. The first location would involve a single track closure gate at 63rd Street and Ashworth Road. This gate would be constructed of steel and span twenty feet. A detail of this gate is shown on plate 43 enclosed. The second location is along the same track and is approximately 2300 feet northwest of the first location. This gate would include two swing gates and span 48 feet. One gate is located on a spur track and the other on your mainline track. A detail of this gate is shown on plate 46.

The single gate closure at Ashworth Road has a frequency of closure of once in four years (a 25% chance of being closed in any given year). The double gate closure has a frequency of closure of once in 10 years (a 10% chance of being closed in any given year). This track is located along Walnut Creek in West Des Moines which is a very flashy stream. Closing of the gates will be the responsibility of the City of West Des Moines, Iowa, when the project is completed. They will need to notify your local yard operator when flash flooding is predicted. Our hydraulic predications indicate that the gates would only be closed for 24 hours at the longest to protect the City under the worst conditions.

The City will need to secure all necessary easements and rights from the railroad to complete this project. We will be designing the closure structures for the City. We would like to establish a good working relationship with the proper design people on your staff to establish clear and open lines of communication during our preparation of plans and specifications.

We are providing several pertinent plates out of our latest design memorandum for your information and review. A copy of our latest Design Memorandum will be furnished to you when it is available for public distribution. Please review our design concepts that we have presented on the enclosed plates. We intend to follow these concepts unless objection is voiced from your office. All structures will be designed in accordance with A.R.E.A. standards. If you have any questions regarding our plans, please contact Mr. Keith Haas of our office at (309)788-6361, extension 6507. Mr. Haas is the project engineer coordinating the technical aspects of this project.

We look forward to working with you on this project in the near future.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

Copy Furnished (w/encl):

Mr. J. W. Farmer
Division Engineer
Norfolk-Southern Corporation
1735 E. Condit
Decatur, Illinois 62521

Mr. Jose Rameriz
Track Superintendent
Norfolk-Southern Corporation
222 SW 11th Street
Des Moines, Iowa 50309

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P O BOX 2004
ROCK ISLAND, ILLINOIS 61204 2004

REPLY TO
ATTENTION OF

January 10, 1991

Engineering Branch
Civil Engineering Section

Mr. Bill Duggan
Vice President - Engineering
Iowa Interstate Railroad LTD.
800 Webster Street
Iowa City, Iowa 52240

Dear Mr. Duggan:

We are currently completing a Design Memorandum for a flood control project in West Des Moines and Des Moines, Iowa along Walnut Creek and the Raccoon River. This project will involve the construction of earthen levees and concrete retaining walls in these cities. The project will also cross several railroad tracks in the Des Moines area. We believe that the project will cross a track under your ownership. A sandbag closure is currently planned near Jordan Creek and two bicycle path crossings are also planned.

We are furnishing you with several plates from the report detailing our work in the area. Please review these drawings to see if the track in question is indeed operated by your company. A copy of a complete Design Memorandum will be furnished to you when it becomes available. Our project will need to be coordinated with you in more detail as we develop final plans and specifications in the future.

If you have any questions or comments regarding our project, please contact Mr. Keith Haas at (309)788-6361, extension 6507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure
Copy Furnished:

Duane Wittstock
City Engineer
1514 Fuller Road
West Des Moines, Iowa 50265

319-338-8641

January 17, 1991

Mr. Robert W. Kelly, P.E.
Department of The Army
Rock Island, Corps of Engineers
Clock Tower Building - P.O. Box 2004
Rock Island, IL 61204-2004

Dear Mr. Kelly:

I am writing in response to your letter to our Mr. Duggan of January 10, 1991, and have the following observations and comments:

1) The trackage and Real Estate effected by your proposal is owned and operated by the Chicago Northwestern Railroad, although we do operate our trains through out the project area via a trackage rights agreement with the above mentioned Railroad.

   Our ownership begins at the intersection of the centerline of the track and a line normal to said track centerline located 362 feet westerly of the north/south centerline of Section 21, Township 78 North, Range 25 West of the 5th P.M., as measured along said track centerline; then westerly along said track centerline through Sections 21, 28, 29 and 30, Township 78 North, Range 25 West of the 5th P.M.

2) Iowa Interstate Engineering staff feels confident that the Chicago Northwestern would join in our opposition of any sand-bagging proposals across the mainline.

If I can be of further assistance in this matter, please contact me at the above number.

Sincerely,

IOWA INTERSTATE RAILROAD

Stephen W. Whitmore
Real Estate - Manager

SWW:dsc

Operations Office
800 Webster Street
Iowa City, IA 52240-4806

General Information (319) 338-8609
24 Hour No. (319) 354-9003
FAX (319) 338-3679

HAAS/tb/6507

February 7, 1991

Design Branch
Civil Engineer Section

SUBJECT: West Des Moines - Des Moines, Iowa, Local Flood Protection Project

Mr. L.P. Vanderleest
Manager, Engineering Services
Chicago and Northwestern Transportation Company
One North Western Center
165 North Canal Street
Chicago, Illinois 60606

Dear Mr. Vanderleest:

We are currently completing a Design Memorandum for the West Des Moines - Des Moines, Iowa, Local Flood Protection project. We will be preparing plans and specifications for this project in 1991. This flood control project will cross the Chicago & Northwestern tracks at two locations as shown on plate 1. The first location would involve a double track closure gate near Railroad Avenue and 63rd Street in Des Moines, Iowa. This gate would be constructed of steel and span forty feet. A detail of this gate is shown on plate 41 and the plan and profile is shown on plate 12. The second location is southwest of the first location about 1.5 miles. This closure would be a sandbag closure located above the 100-year flood profile. The plan and profile is shown on plate 4.

The double gate closure has a frequency of closure of once in 33 years (a 3% chance of being closed in any given year). Closing of the gates will be the responsibility of the City of Des Moines, Iowa, when the project is completed. The second closure has a frequency of closure of once in 300 years. The track elevation is above the 100-year flood elevation. Our line of protection includes the 100-year flood level plus four feet of freeboard above that level. A 300-year flood has a 0.3% chance of happening in any given year. The City will need to notify your local roadmaster when flooding is predicted on the Raccoon River and the closures will be made.

Our topographic maps indicate that the tracks east of the closure structure will be underwater prior to closing of the gate. The floodwaters will have already stopped trains from running on these tracks prior to the closing of our gates. As soon as floodwaters recede, the gates will be opened and the sandbag closure removed. Hydraulic studies indicate that the gate would need to be closed for a few days at the most. This would depend upon the severity of the flooding (i.e. 50-year, 100-year, etc.).

The City will need to secure all necessary easements and rights-of-way from the railroad to complete this project. We will be designing the closure structure for the City. All structures will be designed in accordance with A.R.E.A. standards. We would like to establish a good working relationship with the proper design people on your staff to establish clear and open lines of communication during our preparation of plans and specifications.

A copy of our latest Design Memorandum will be furnished to you when it is available for public distribution. Please review our design concepts that have been presented on the enclosed plates. We will be contacting your office in February 1991 to schedule a meeting to discuss our proposed plans and construction schedules and the Interstate Railroad's concerns about the proposed sandbag closure. The Interstate Railroad has concerns about the proposed sandbag closure across the track which they expressed in a 17 January 1991 letter to me.

If you have any questions regarding our plans, please contact Mr. Keith Haas of our office at (309)788-6361, extension 6507. Mr. Haas is the project engineer coordinating the technical aspects of this project.

Sincerely,

ORIGINAL SIGNED BY

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P O BOX 2004
ROCK ISLAND ILLINOIS 61204 2004

REPLY TO ATTENTION OF

January 10, 1991

Design Branch
Civil Engineering Section

Mr. Bob Meckiman
Martin Marietta Aggregates
11197 Aurora Avenue
Urbandale, Iowa 50322

Dear Mr. Meckiman:

We are currently completing a Design Memorandum for a flood control project in West Des Moines and Des Moines, Iowa along Walnut Creek and the Raccoon River. This project will involve the construction of earthen levees and concrete retaining walls in these cities. We have planned a railroad closure structure where our levee crosses the track supplying your bulk material operation in West Des Moines. This structure would also allow truck access to your facility.

We are furnishing you with a general plan and several detailed plates concerning this railroad closure structure. Please review these details and inform us if you have any comments or problems with the proposed structure. We are assuming that your operation will remain intact in the West Des Moines area. If this spur track is to be abandoned in the near future, please let us know.

If you have any questions regarding the project, please contact Mr. Keith Haas at (309)788-6361, extension 6507.

Sincerely,

Robert W. Kelley, P.E.
Chief, Engineering Division

Enclosure

Copies Furnished:

Mr. Jack Jeffs
Martin-Marietta
620 South 11th Street
West Des Moines, Iowa 50265

Mr. Duane Wittstock
City Engineer
1514 Fuller Road
West Des Moines, Iowa 50265

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DIRECTOR, FEDERAL EMERGENCY MANAGEMENT AGENCY REGION VII, 911 WALNUT STREET - ROOM 300 KANSAS CITY MO 64106	
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MR ROBERT STOECKER, ASSISTANT ROAD DESIGN ENGINEER IOWA DEPT OF TRANSPORTATION, 800 LINCOLN WAY AMES IA 50010	R
DEPARTMENT OF TRANSPORTATION, ATTN MR DON EAST OFFICE OF ROAD DESIGN, 800 LINCOLN WAY AMES IA 50010	R
DIRECTOR, IOWA DEPT OF SOIL CONSERVATION WALLACE STATE OFFICE BLDG, 900 EAST GRAND AVENUE DES MOINES IA 50319	
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HONORABLE MARY E KRAMER, IOWA SENATOR-41ST DISTRICT STATE CAPITOL BUILDING, DES MOINES IA 50319	
HONORABLE JOHN H. CONNORS, IOWA REPRESENTATIVE-79TH DISTRICT 1316 EAST 22ND ST, DES MOINES, IA 50317	
HONORABLE DOROTHY F. CARPENTER, IOWA REPRESENTATIVE-82ND DISTRICT 1100 - 24TH STREET, WEST DES MOINES, IA 50265	
EXECUTIVE DIRECTOR, POLK COUNTY CONSERVATION BOARD JESTER PARK, GRANGER, IA 50109	
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